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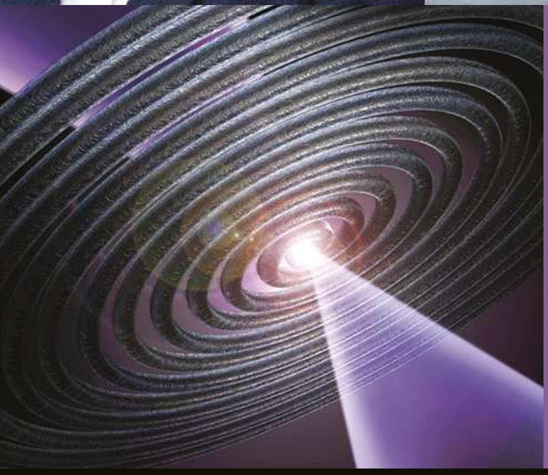

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Welcome

Two planets and an astronaut rule the skies of June

On 18 June, Tim Peake will strap himself into a Soyuz re-entry capsule and say goodbye to his orbital home. With his time on the ISS at an end, a fiery descent through Earth's atmosphere down to the Kazakh Steppe awaits. On page 43 we celebrate his time in space and look ahead to what the future holds for him.

For those of us with our feet on the ground, there are two planets that are ripe for observing in the coming month. Mars reaches opposition on 22 May, when it'll be at its highest and brightest. Turn to page 68 to read Paul Abel's account of the seasons of Mars and what changes can be observed in the weeks ahead.

Beguiling Saturn follows it to opposition on 3 June, and though its low altitude from the UK means it's not a great apparition for imaging, to visual observers it will be a magical sight. Paul Money discusses why the ringed gas giant captures hearts and minds on page 39, while Pete Lawrence covers the opposition in detail in the *Sky Guide* on page 52. And staying with Saturn, on page 32 Will Gater looks ahead to the dramatic end of the Cassini mission.

Enjoy the issue!

Chris Bramley Editor

PS Next issue goes on sale 23 June

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This month's contributors include...

BRIAN JONES
ASTRONOMY AUTHOR

Brian reveals the power of parallax, and how this age-old observing technique is helping us understand the cosmos. *Page 80*

PETE LAWRENCE
ASTRONOMY EXPERT

Saturn is the star of this month's Sky Guide, where Pete explains how to get the most out of the planet visually and with a camera. *Page 52*

MATT ROBINSON
IAPY RUNNER UP

Matt won a runner up award at IAPY 2015 with his shot of noctilucent clouds. Now he shares his NLC editing secrets. *Page 84*

NICK SPALL
SPACE WRITER

Nick looks back on Tim Peake's six-month stint on the ISS ahead of the astronaut's return to Earth on 18 June. *Page 43*

Sky at Night LOTS OF WAYS TO ENJOY THE NIGHT SKY...

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Find out what *The Sky at Night* team will be exploring in this month's episode on page 19

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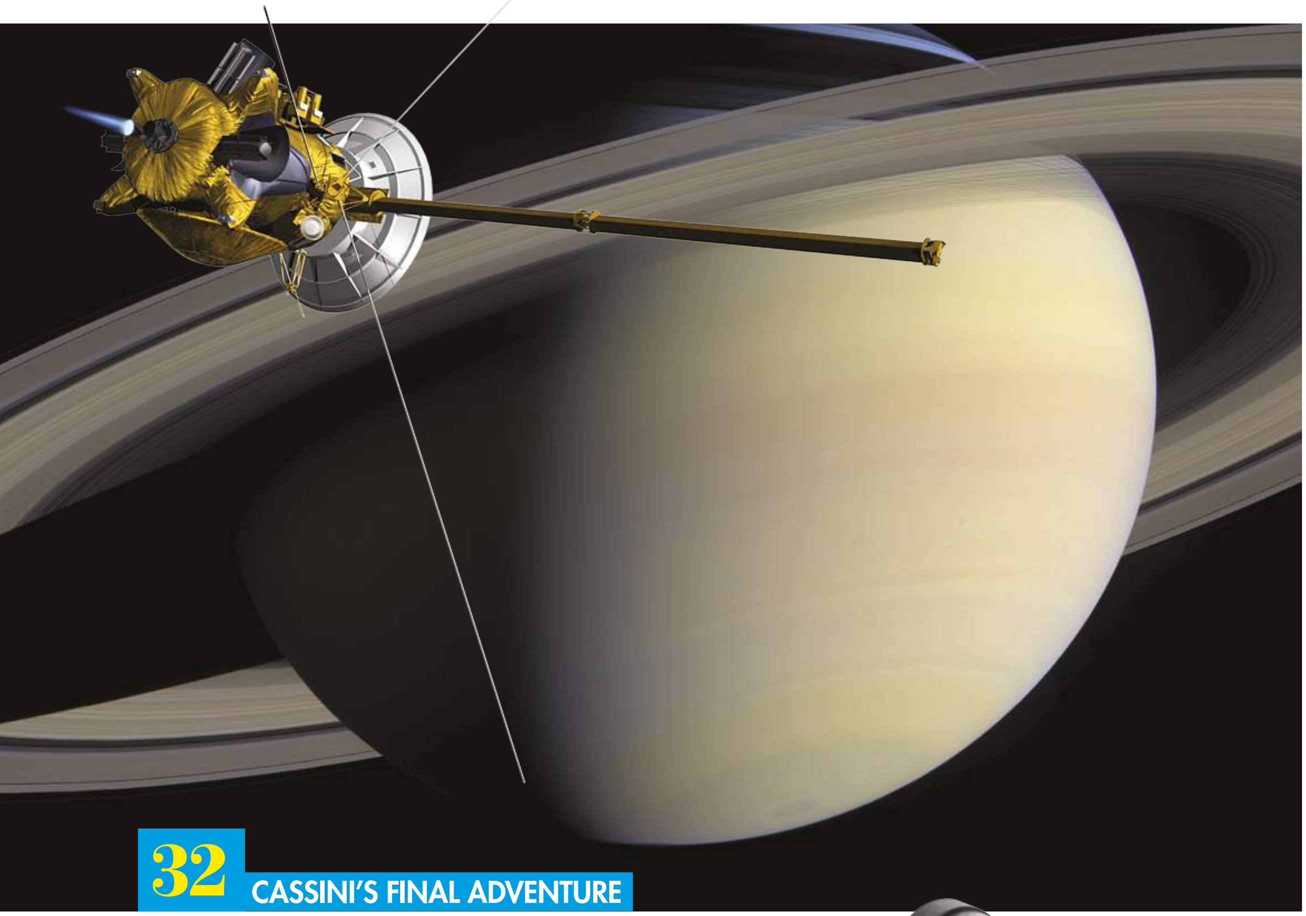
NEW TO ASTRONOMY?
See *The Guide* on page 80 and our online glossary at www.skyatnightmagazine.com/dictionary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Ⓒ As Tim Peake prepares to leave the ISS, we reflect on his mission and what lies ahead.

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THIS MONTH'S ACCESS CODE IS: WQD3Y5B

HOW TO CAPTURE A GRAVITATIONAL WAVE

The detection of gravitational waves by the LIGO experiment is one of the most significant scientific advancements ever achieved. But what is the real story behind its seemingly complex physics, and what comes next? This issue we speak to Dr David Reitze, executive director of LIGO, to get the answers to these questions.

HIGHLIGHTS

SKY AT NIGHT EPISODE

April's episode looks at the recent discovery of gravitational waves and what it means for black hole theory. Prof Stephen Hawking joins the team to explain his own research into the subject, while Chris and Maggie explore the cosmic event that led to the discovery.

TIM PEAKE'S PRINCIPIA MISSION: BEST BITS

As the British astronaut's time on the ISS comes to an end, we present some highlights of Tim's journey via the videos sent back to Earth.

THE FUTURE OF HUBBLE SPACE TELESCOPE

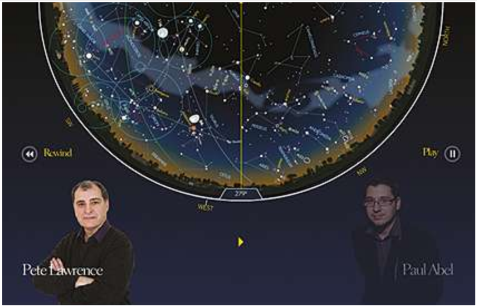
In April, Hubble marked 26 years of capturing the cosmos. This Hubblecast video reveals what the space telescope has yet to offer.

EVERY MONTH

VIRTUAL PLANETARIUM

With Paul Abel and Pete Lawrence

Take a tour of June's night-sky highlights with Paul and Pete.



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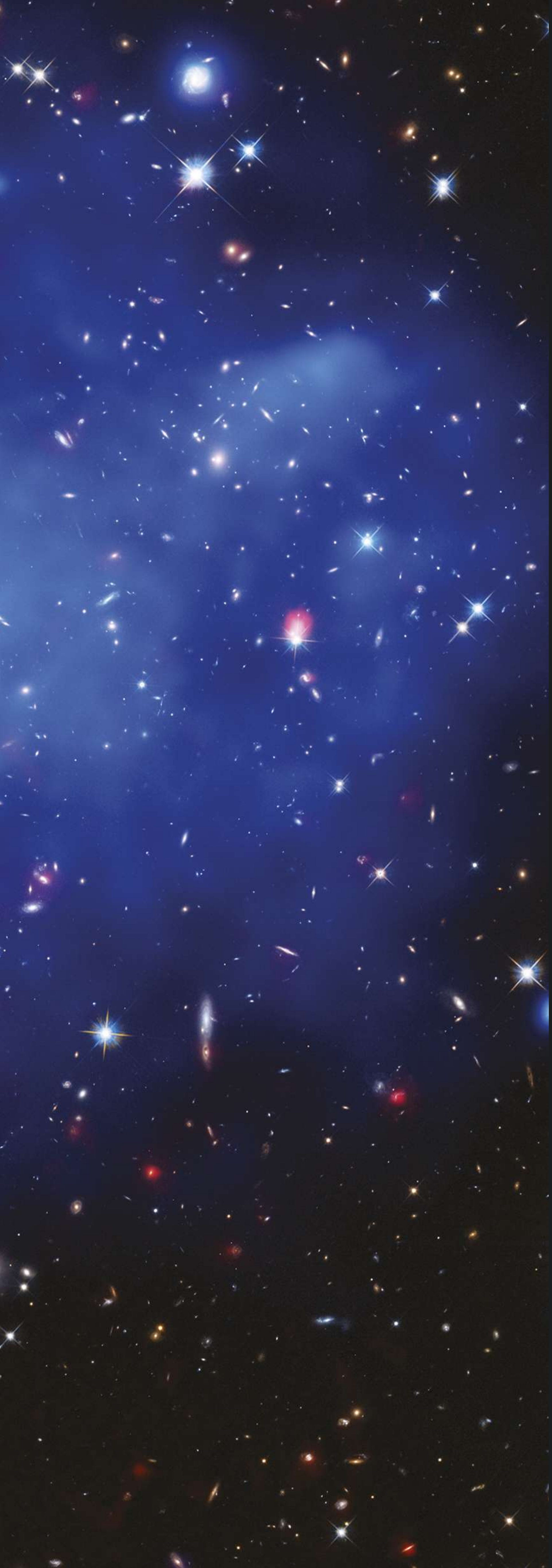


TAP HERE for more stunning photos

Trick of the light

Astronomers are using galaxy clusters as natural magnifying glasses to reveal the secrets of the Universe that would otherwise be just out of reach

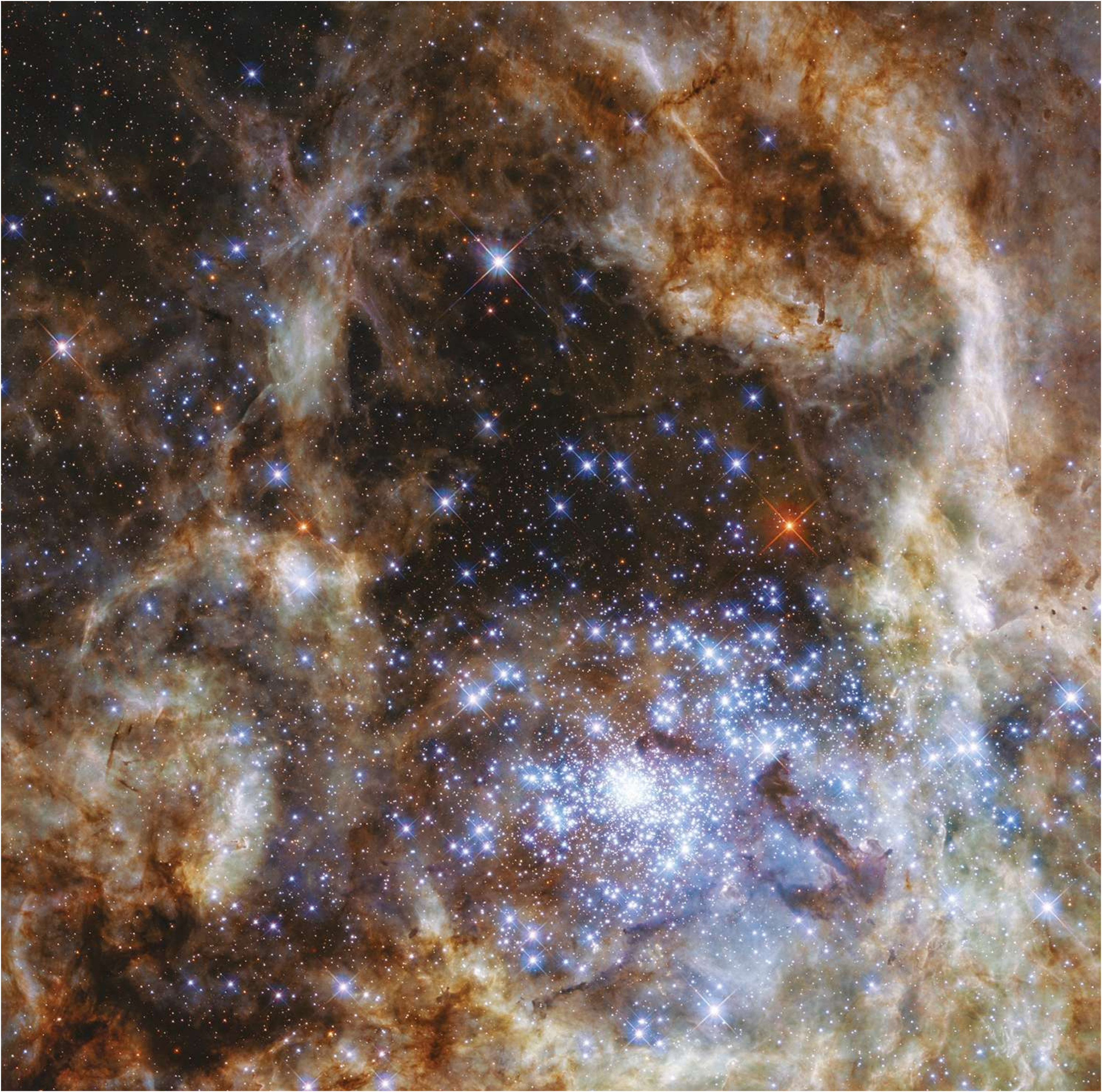
CHANDRA X-RAY OBSERVATORY, HUBBLE SPACE TELESCOPE & JANSKY VERY LARGE ARRAY, 14 MARCH 2016

This chaotic-looking object called MACS J0717 is the result of a violent collision and merger between four galaxy clusters located about 5.4 billion lightyears away from Earth.

The image is part of the Frontier Fields project, which uses the Hubble Space Telescope to examine galaxy clusters in a quest to learn more about the evolution of the Universe. These clusters are so massive that their gravity warps and magnifies the light of distant galaxies located farther away from Earth, a process known as gravitational lensing. Hubble is able to capture this magnified light, revealing the secrets of some of the most distant galaxies ever encountered. Without this technique, many of the galaxies could not be studied at all.

Seven gravitationally lensed points were identified in the Jansky VLA data of MACS J0717, seen in pink. These are seven galaxies located between 7.8 billion and 10.4 billion lightyears from Earth, visible at radio wavelengths. Two of the sources were also detected by Chandra, the data from which is seen as blue here, and this is likely to be due to the presence of active galactic nuclei (AGN). AGN are dense regions that shine brighter than normal, powered by cosmic gas that has been heated to millions of degrees Celsius as it falls toward the supermassive black holes at the galaxies' centres. Without the gravitational lensing technique employed in the Frontier Fields project, these sources would either appear much fainter, or elude observation entirely.

X-RAY: NASA/CXC/SAO/GOGREAN ET AL; OPTICAL: NASA/STSCI; RADIO: NRAO/AUI/NSF



▲ Stellar giants

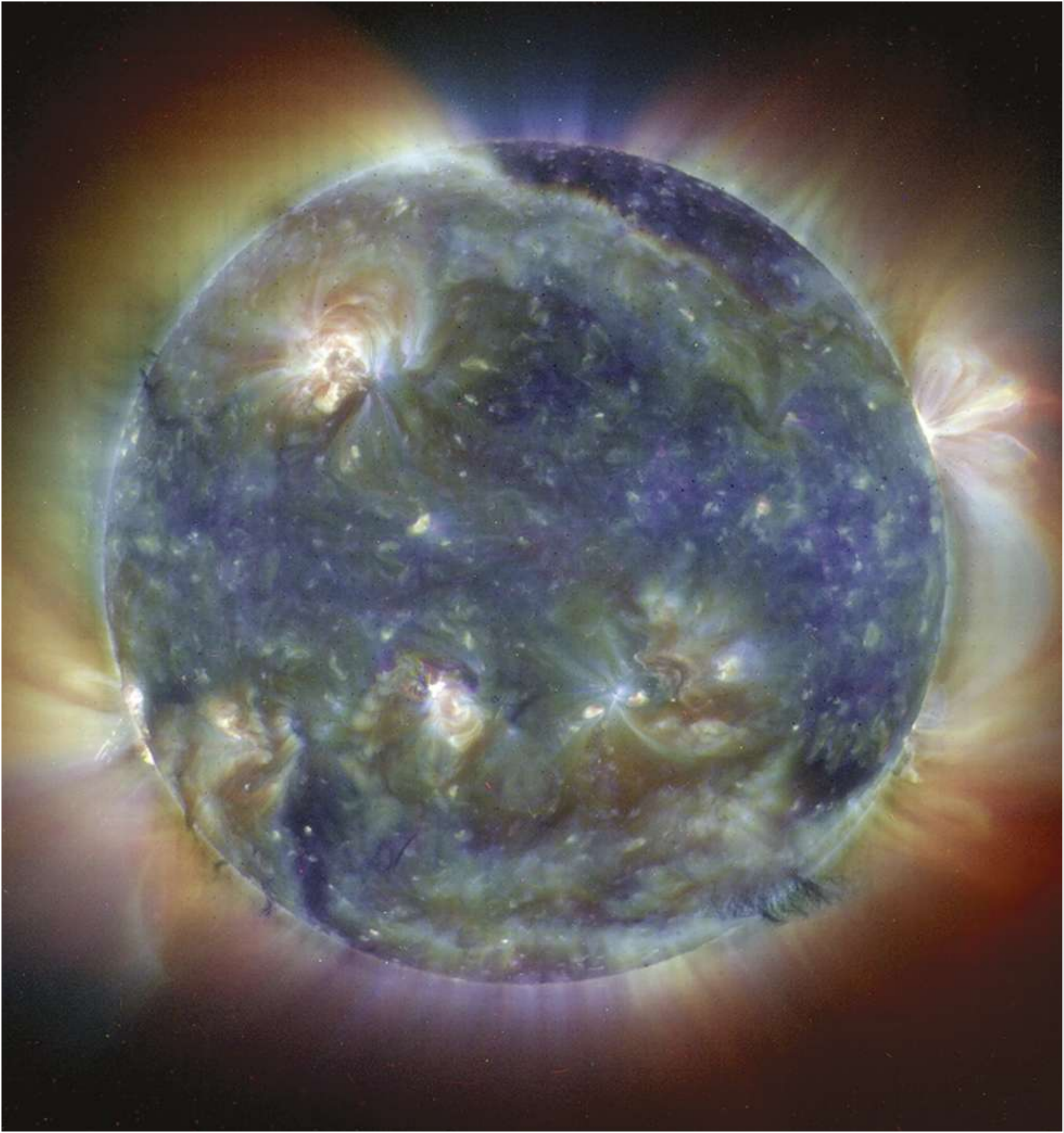
HUBBLE SPACE TELESCOPE, 17 MARCH 2016

The densely packed blue glow of star cluster R136 reveals the youthful vibrancy of stellar formation in this Hubble image. Dozens of stars over 50 times the mass of our Sun have been discovered in this cluster, while nine stars have been spotted that are over 100 times more massive. Together, these stars produce an output greater than that of the Sun by a factor of 30 million.

Tim's lunar shot ▶

TIM PEAKE, 4 APRIL 2016

Many astrophotographers are prepared to traverse the globe in search of that perfect shot, but what better vantage point currently exists than the International Space Station, orbiting some 400km above Earth? This image of our Moon was captured by British astronaut Tim Peake on board the ISS and shared with his many followers via social media.



◀ Mapping the solar atmosphere

SOLAR AND HELIOSPHERIC OBSERVATORY, 21 MARCH 2016

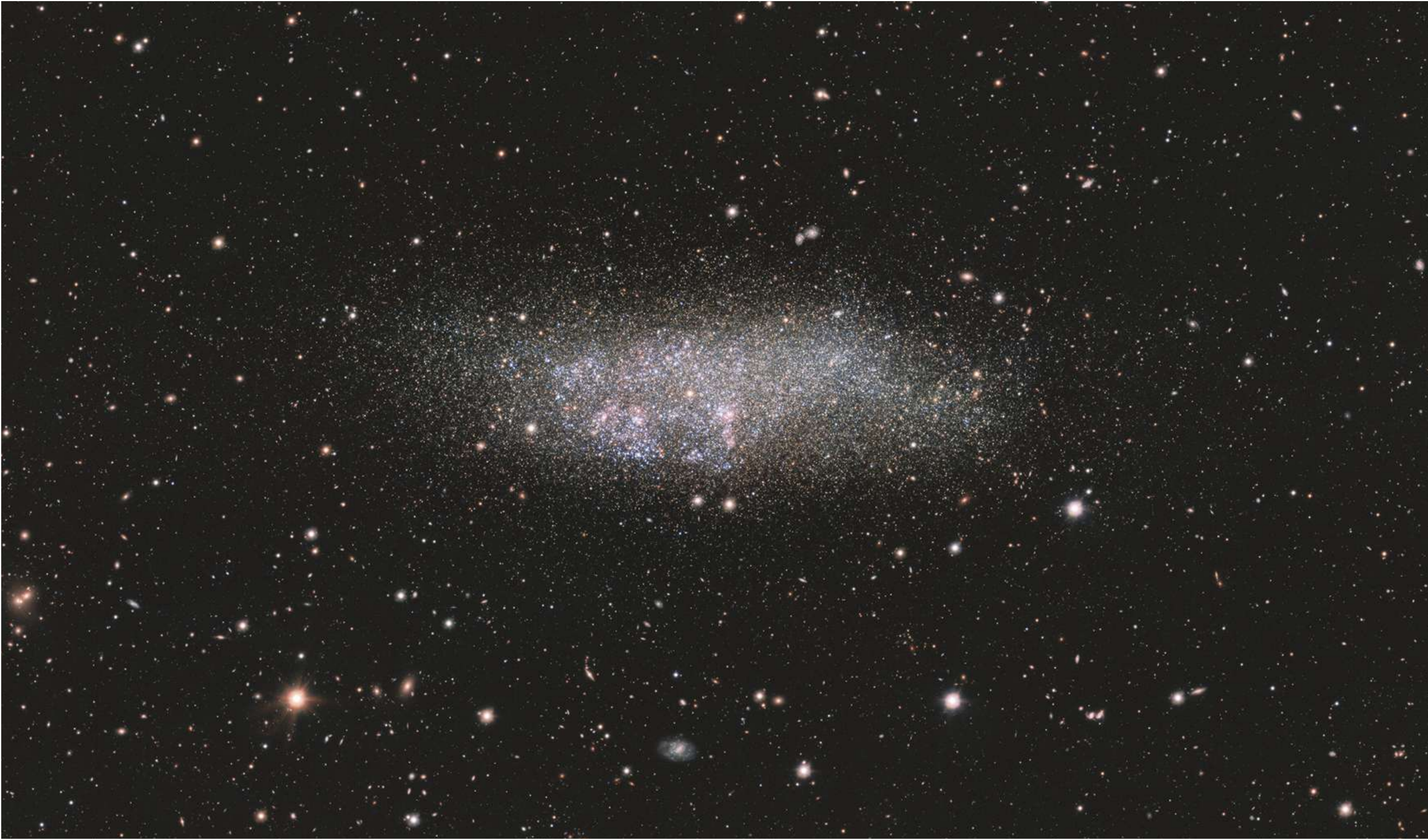
The Solar & Heliospheric Observatory (SOHO) is a joint project between ESA and NASA to study the Sun in detail. This image shows our host star in three wavelengths, highlighting the varying temperatures of gas in the Sun's atmosphere, the corona. The temperature differences can be traced by analysing the iron atoms: blue shows iron at a temperature of one million degrees Celsius, yellow at 1.5 million degrees and red at 2.5 million degrees.

▼ The lone wolf

VERY LARGE TELESCOPE, 23 MARCH 2016

This lonely-looking object is Wolf-Lundmark-Melotte (WLM), an irregular galaxy found on the outer edges of the Local Group, the collection of galaxies that includes the Milky Way and the Andromeda Galaxy. WLM is so remote that astronomers believe it may never have interacted with any other Local Group member, or indeed any galaxy in the Universe.

NASA/ESA/P CROWTHER (UNIVERSITY OF SHEFFIELD), ESA/NASA, SOHO (ESA & NASA), ESO



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Bulletin

The latest astronomy and space news written by **Elizabeth Pearson**

PLUS CUTTING EDGE

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Our experts examine the hottest new astronomy research papers

Supernova ash rains down ON EARTH

An exploded star's wreckage is passing through our Solar System

RADIOACTIVE DEBRIS FROM one of the closest supernovae to Earth has been identified speeding through our Solar System. The discovery of the cosmic rays places at least one supernova within 300 lightyears of Earth in the past three million years.

High velocity particles of the incredibly rare iron-60, an isotope of iron that's seldom created outside of supernovae, were detected by the Advanced Composition Explorer (ACE) satellite. Though only 15 atoms of the isotope were picked up in 17 years' of observations, this is sufficient to infer that they must have originated in a supernova.

As the half-life of iron-60 is only 2.6 million years, finding these atoms in the Solar System means a nearby explosion must have happened within the past few million years. But for the atoms to reach the speeds needed to cross hundreds of lightyears would require a significant push; in this case a second supernova.

"The [iron-60] must have been sitting around for a few hundred thousand years before the shockwave of another supernova accelerated them," says Martin Israel from Washington University in St Louis. "The cosmic rays must have come from a region of the Galaxy where supernovae are going off every few million years."

The most likely candidate is an OB association, which are groups of many massive, hot stars. However, pinpointing the precise culprit is difficult because cosmic rays are scattered by the galactic magnetic field, masking their origin. It is likely that the source was within 300 lightyears of Earth, as that is how far these kinds of particles can travel in the times involved.

"There are a number of OB associations within a few hundred lightyears of us. But you can't point to one and say it definitely came from there," says Israel.

The announcement comes shortly after two other research groups found the same rare isotope on the ocean floor and in lunar soil. These groups managed to pin down the date more precisely to between 1.7 and 3.2 million years ago. Now the search is on for other supernova leftovers which may remain on and around Earth.

▸ **See Comment, right**

The radioactive leftovers discovered in space have already been found on Earth's ocean floor

CLAUS LUNAU/SCIENCE PHOTO LIBRARY, NASA

COMMENT

by Chris Lintott

These spectacular results might well make you feel uneasy. Here is cast-iron evidence that a powerful explosion happened nearby within the past few million years, less than 300 lightyears away. Should we be worried?

Life on Earth did have a bad time just around then: 2.6 million years ago was the transition between the Pliocene and Pleistocene epochs, between which a large number of marine species, including many plankton and molluscs, went extinct. It's possible that these were species particularly sensitive to the ultraviolet flash of a nearby supernova, or that the timing is a coincidence.

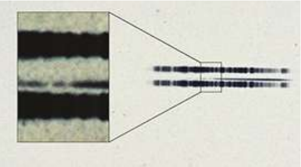
Either way, this latest discovery is a reminder that our fate is tied to our cosmic surroundings. We are all made of supernova remnants, and our neighbourhood has been shaped by the fate of many exploding stars. Understanding our own planet's history means using all sorts of evidence to tell this increasingly complicated story.

CHRIS LINTOTT co-presents *The Sky at Night*

NEWS IN BRIEF

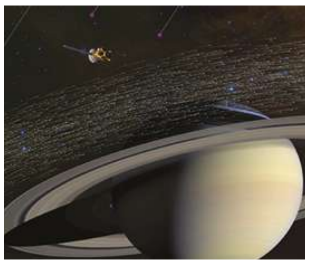
FIRST EXOPLANET EVIDENCE WAS RECORDED IN 1917

An image thought to be the first known evidence for the discovery of an exoplanet has been found in a basement nearly a century after it was taken in 1917. The image shows the spectrum of a white dwarf known as Van Maanen's star, which includes a dark absorption line caused by starlight filtering through a cloud of material rich in calcium, iron and magnesium. We now recognise this as planetary debris left from an exoplanet's formation. The photographic plate was rediscovered after scientists requested it from Carnegie Science's archives while writing a paper on the planetary system now known to surround the white dwarf.



CASSINI FINDS INTERSTELLAR DUST

Dust from beyond our Solar System has been found around Saturn. The Cassini spacecraft's dust analyser collected 36 grains, the composition of which points to an origin in interstellar space. They had been travelling at 72,000km/h. The grains were remarkably similar to each other in composition, made from rock-forming elements rather than ices.



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MOON MAINTAINS EARTH'S MAGNETIC FIELD

The constant pull of our lunar companion drives our planet's core

OUR CELESTIAL COMPANION has been keeping us safe from the harsh radiation of the Sun for billions of years, according to a new study. The gravitational pull of the Moon has been helping to drive the Earth's magnetic field, which deflects harmful solar rays.

The Earth's magnetic field is created by rapid motions of liquid iron in the outer layer of the Earth's core, creating what's called a geodynamo. The movement induces an electric current, which in turn creates a magnetic effect.

"To produce this motion you need some power source. One of the main explanations was that the turbulence created from heat from the centre of the Earth transferring to the core-mantle boundary created this motion," says Denis Andrault from Université Blaise Pascal.

To create the power needed Earth would have had to cool by 3,000°C. But the Earth's core is still a scorching 3,800°C, hot enough for the mantle to be kept on the cusp of melting. We know the core was not 6,800°C in the past, since the molten mantle would have had a different chemical composition to what we see today. Instead, the energy must come from something other than cooling – and the prime suspect is the Moon.

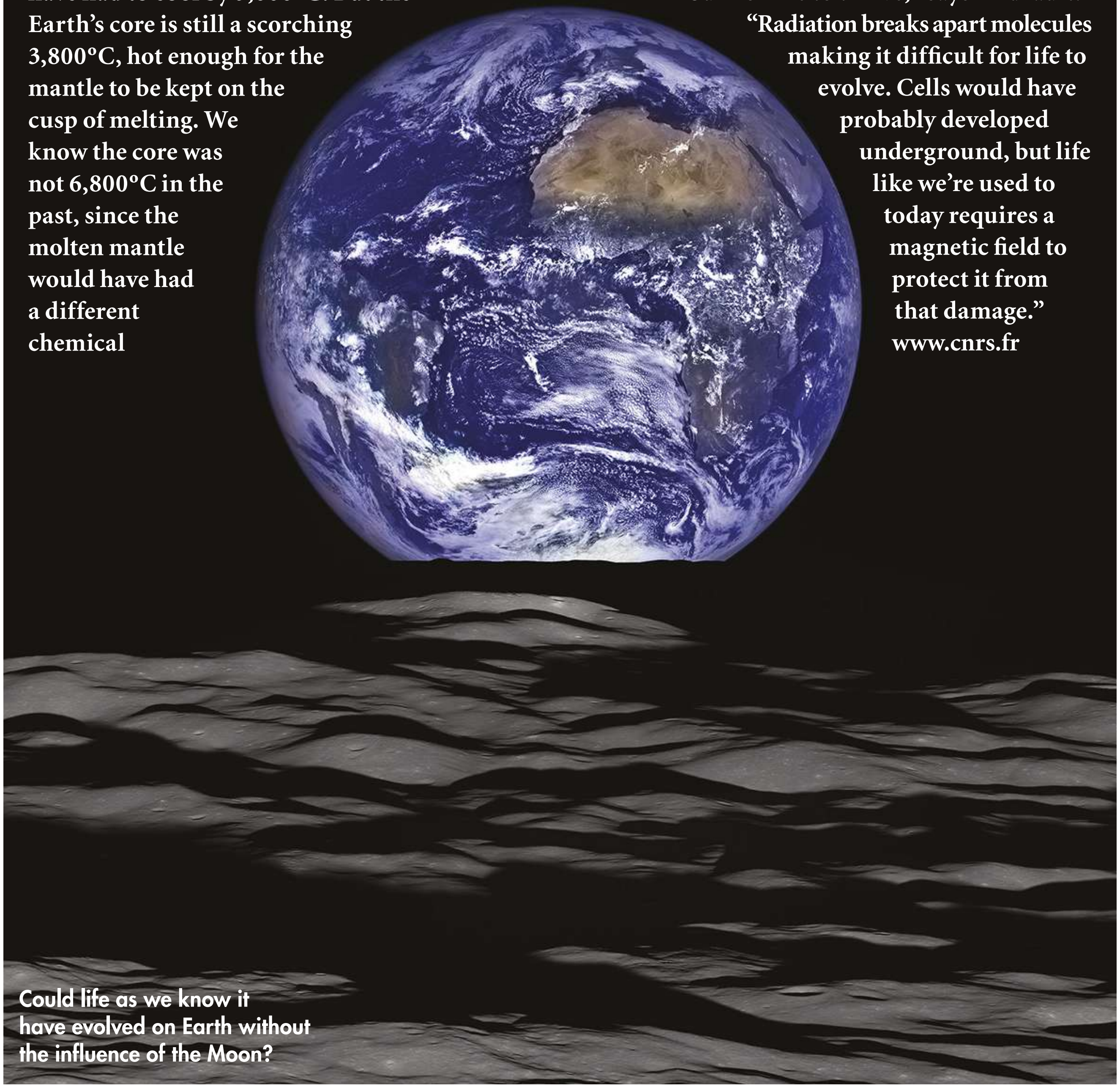
"The energy input into the core from the Earth-Moon gravitational system is greater than the total global production of electricity in the world; 3.7 trillion watts," says Andrault. "Most of this is used in moving the water in the oceans, but it also goes into the mantle."

The estimated one billion watts added to the core reduces the cooling needed to a much more reasonable 300°C.

For billions of years the Earth's magnetic field has protected life on the surface from being bombarded by solar radiation. In the hunt for life, searching for exomoons – and thus planets with magnetic fields – may be important.

"There's too much radiation coming from the Sun for life to thrive," says Andrault. "Radiation breaks apart molecules making it difficult for life to evolve. Cells would have probably developed underground, but life like we're used to today requires a magnetic field to protect it from that damage."

www.cnrs.fr



Could life as we know it have evolved on Earth without the influence of the Moon?

Inflatable extension added to ISS

Similar blow-up habitats could one day be sent to Mars

THE INTERNATIONAL SPACE Station is about to get an extension after the installation of the first ever expandable space module on 16 April. The module will serve as a test for technology that could be used to build the large spacecraft needed for long-haul crewed missions.

The Bigelow Expandable Activity Module (BEAM) will be inflated at the end of May to approximately 3x4m, and astronauts will regularly enter it to test its safety.

"The space station provides an ideal laboratory to test the BEAM expandable module in the harsh environment where it will have to operate," says Julie Robinson, NASA's chief scientist for the ISS. "Attaching this expandable module to the space station offers NASA the opportunity to expose it to the radiation, temperatures, pressures and micrometeoroid environment, and measure how it holds up."
http://bigelowaerospace.com

▲ Inflatable habitats could see a future use in space or on other planets, should this test prove a success

HAWKING'S MISSION TO ALPHA CENTAURI

A NEW MISSION that is shooting for the stars was announced on 12 April by physicists Stephen Hawking and Yuri Milner. The Breakthrough Starshot project will test technology that could allow spacecraft to traverse the 4.4 lightyears to star Alpha Centauri in as little as 20 years, opening the way for interstellar travel.

The mission will test the feasibility of accelerating tiny spacecraft that weigh only a few grams, called nanocraft, to as much as 20 per cent the speed of light using ground-based lasers. Though the concept has been a staple of science fiction for decades, it's only now that technology has been able to match the human imagination. If the principle is proven it could provide a way to traverse the vast distances between stars and greatly increase the horizons of human exploration.

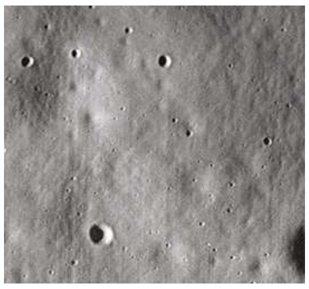
"We take inspiration from Vostok, Voyager, Apollo and the other great missions," says Pete Worden, executive director of Breakthrough Starshot. "It's time to open the era of interstellar flight, but we need to keep our feet on the ground to achieve this."
http://breakthroughinitiatives.org

Hawking, Milner (third from left) and the rest of the Breakthrough Starshot launch team

NEWS IN BRIEF

MESSENGER'S FINAL IMAGE

After five years and more than 4,000 orbits of Mercury, the Messenger probe's mission came to a dramatic end on 30 April when the NASA satellite was deliberately slammed into the planet's surface. Travelling at 14,080km/h, the 3m-wide spacecraft is thought to have created a new crater measuring 16m across on the planet's northern hemisphere; the impact went unobserved as it was on the opposite side of Mercury to Earth. Launched in 2004, Messenger (whose last image is below) was the first probe to orbit Mercury. Its achievements include discovering the planet's surface composition and internal magnetic field.



JWST MIRROR UNVEILED

The 6.5m primary mirror of the James Webb Space Telescope has been revealed in its full golden glory. It will go on to detect light from the first stars, but it is so large it has to be carefully folded to fit inside the launch rocket. Engineers will now attach and test the scope's main instruments behind the mirror.

CUTTING EDGE

Our experts examine the hottest new research

Measuring expansion

Arriving at a value for the Hubble constant is a significant piece in the puzzle of the cosmos

▲ **Hubble's mission goals extend far beyond the iconic astrophotos for which it is famed**

ISTOCK

The clue is in its name: one of the primary goals of the Hubble Space Telescope has been to measure the Hubble constant. This important number, H0 (pronounced 'H-naught'), represents the rate at which the Universe is currently expanding. Measuring it is key to testing our theories of cosmology, and pinning down its value was a central debate before the space telescope's results brought some clarity.

So how do we work out H0? Start by measuring the redshift of a set of distant galaxies. But that's only half the story. To turn those observations into a measure of the rate of expansion, we need to know how far away the galaxies are, and it's here that the Hubble Space Telescope comes in. With its superior, sharper vision it can look for a specific type of star – a Cepheid variable. These variable stars pulse with a period that depends on their luminosity. The brighter the star, the slower they pulse.

This means that when you observe a Cepheid you get two pieces of information: its apparent brightness, and the 'true' brightness indicated by the period. Put the two together and you get a measure of distance which, combined with the redshift, is all you need to determine the Hubble constant. The original Hubble observations settled on a value a shade above 70 kilometres-per-second-per-megaparsec, meaning that for every megaparsec (a bit more than three million lightyears) of space between us and a galaxy we measure an expansion of 70km every second.

CHRIS LINTOTT is an astrophysicist and co-presenter of *The Sky at Night* on BBC TV. He is also the director of the Zooniverse project.

This value can be compared those found from studying of the cosmic microwave background (CMB). But as new telescopes improve the accuracy of our observations of the CMB, there's a need for the local observations of H0 to improve also.

That's what the most recent paper by the Nobel-winning team led by Adam Riess delivers. They've detected new Type Ia supernovae in 10 galaxies. These explosions, like Cepheids, have a luminosity that can be deduced from observations and used to find their distance.

Using supernovae is less accurate than relying on Cepheids, but they can be seen from much farther away. By observing Cepheids in galaxies that host Type Ia supernovae, this work ties two rungs of the cosmic distance ladder together.

> "Using supernovae is less accurate than Cepheids, but they can be seen from farther away"

As a result, the new reliable value for H0 is 73 kilometres-per-second-per-megaparsec, to an accuracy of 2.4 per cent. That's not too different from the previous value, but it is still significantly higher than the best estimate from Planck observations of the CMB.

A discrepancy between the two would be one of the most important results of the last few years, indicating the presence of some as yet unknown fundamental physics operating in the early Universe. Confirmation would be a spectacular new discovery that would challenge not only cosmology but perhaps the standard model of particle physics as well.

Yet I wouldn't jump just yet. Other measurements of the CMB are a better, though not perfect, fit to the Cepheid results. Whatever the situation, we'll only learn more through careful, thorough observational programs, just like the one described here.

CHRIS LINTOTT was reading… *A 2.4% Determination of the Local Value of the Hubble Constant* by Adam G Riess et al
Read it online at http://arxiv.org/abs/1604.01424v1

Since 2015, Helen Sharman has been the operations manager for the department of chemistry at Imperial College London

The first Briton in space

Twenty-five years ago, Helen Sharman became a national hero when she blasted off to the Soviet space station Mir. She recalls her pioneering eight-day mission

IN MAY 1991, Helen Sharman was blasted into orbit from Baikonur Cosmodrome to become Britain's first astronaut. The 27-year-old, selected over 13,000 other hopefuls, would spend the next eight days working on the Soviet space station Mir as part of Project Juno, a privately funded collaboration between the UK and Russia to put the first Briton in space.

JOACHIM BECKER/SPACEFACTS.DE

What drove you to apply for Project Juno?
I applied because I thought it would be fun. I wanted to go for the training as much as the spaceflight; to live in Russia, learn a foreign language, speak with the cosmonauts and to learn about the science of the spacecraft. And if I could go into space, well wouldn't that be amazing!

Looking back 25 years later, which memories stand out?
It has to be the weightlessness, just floating around inside a space station. It's the reason you take experiments into space, and the science was the big thing for me. The other was looking out of the window. I first saw Earth during the launch phase; the ocean with white clouds over it and then that blackness of space above it. Absolutely amazing.

▲ Sharman aboard Mir; she was selected for the mission over 13,000 other hopefuls

What would you say to budding astronauts?
Enjoy your life. Have fun with it. While people should absolutely apply to be astronauts, if you don't get in you still need to enjoy yourself in the process. Back-up plans are something that astronauts live by. Whether it's your emergency oxygen back-up or emergency career back-up, it's always important to have one.

Did you say anything to current UK astronaut Tim Peake before launch?
I reminded him to enjoy those views out of the window. Enjoy those colours of the Earth because they are never quite the same in photographs. It's that vibrancy that I remember, and I hope Tim is enjoying it to this day.

What's changed in the past 25 years of British spaceflight?
When I flew there was no government involvement in human spaceflight. Now I think there is a will to be part of the international group of spacefaring nations. Britain is going to get left behind if we don't. There's a welling of support for Tim, but the government needs to make it clear there will be continued funding for spaceflight. So hopefully there will be a second spaceflight for Tim or another Briton in the not too distant future.

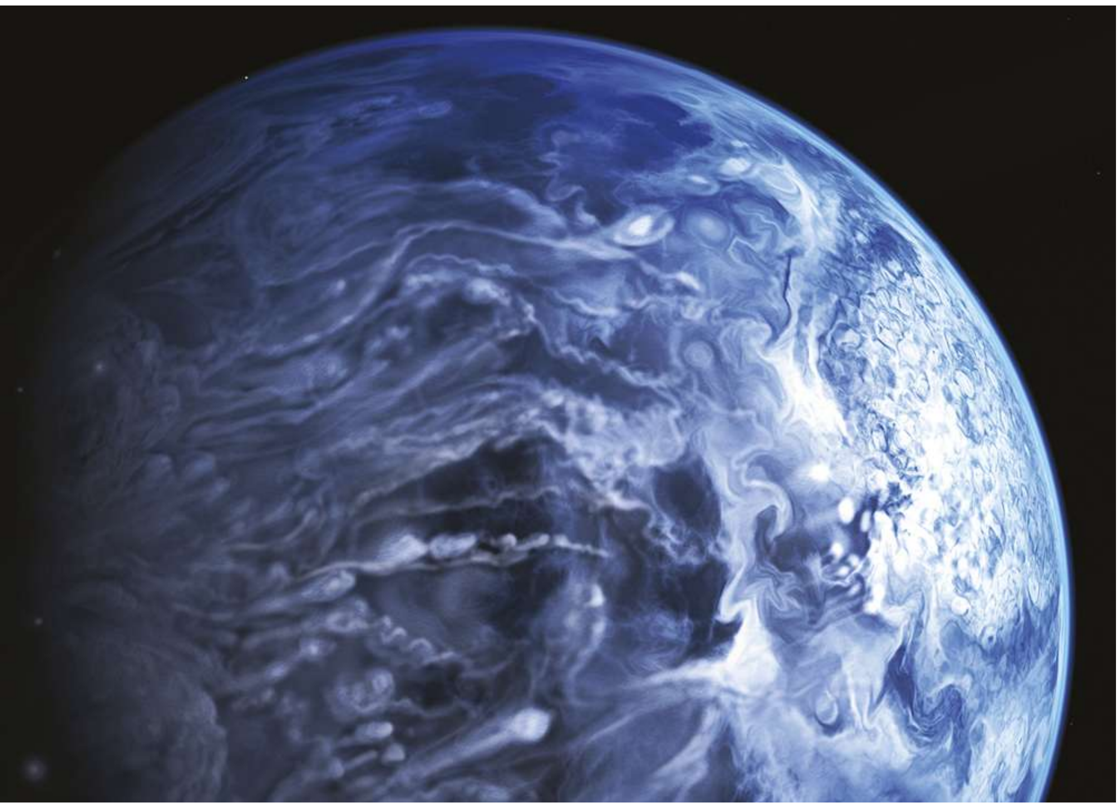
Join Helen Sharman and other European astronauts in conversation at the Science Museum on Saturday 21 May in the IMAX Theatre at 10.30am.
www.sciencemuseum.org.uk/sharman25

CUTTING EDGE

Our experts examine the hottest new research

Clouds of mystery

The extreme conditions of hot Jupiters mean their atmospheres are full of surprises



▲ **Weird weather seems to be the norm for hot Jupiters; on HD 189733 b for example, it rains glass**

NASA/ESA/M. KORNMESSER

On the rocky 'terrestrial' worlds of our Solar System, the clouds are composed of what are known as volatiles; compounds that evaporate and then condense back into liquid droplets or form ice crystals at relatively low temperatures. On Earth, the classic fluffy cumulus clouds are made up of plumes of condensed water vapour, whereas the whispy, streaky cirrus clouds form at much higher altitudes out of tiny crystals of water ice. The clouds of Mars are mostly carbon dioxide ice, whereas the Venusian skies are permanently overcast with thick cloud decks of concentrated sulphuric acid.

The atmospheres of the gas giant planets are slightly more complex, with cloud layers made up of completely different compounds forming over discrete temperature ranges and thus at separate altitudes. In the skies of Jupiter, for example, there are three distinct kinds of cloud layers: water, ammonium hydrosulphide and then ammonia clouds highest of all.

One of the most exciting facets of research into exoplanets, worlds in other star systems, is understanding how very different their atmospheres and weather systems can be. Of course, the gas mixture in an exoplanet's air and the composition and altitude profiles of condensed cloud layers depend on the particular chemical processes being driven in its atmosphere, which ultimately comes down to the kind of star it orbits, and the intensity of the sunlight it receives and the resultant temperature.

Christiane Helling at the University of St Andrews and colleagues have been looking at two particular exoplanets, HD 189733 b and HD 209458 b. These are among the most intensely studied alien worlds to date. Both have orbits that are very tight to their host star, and so they receive a great deal of intense sunlight and have scorching atmospheres; they are both hot Jupiters. To try to better understand their atmospheric dynamics and cloud formation processes, the researchers have been combining the spectroscopic data collected so far with their 3D computer models of planetary atmospheres and the chemical processes driven at different altitudes within them.

While spectroscopic observations have revealed common atmosphere constituents such as water, methane, carbon monoxide, it is the nature of the modelled cloud layers that really stand out for these two extreme gas giants. Helling and team suggest that both planets will have complex, mixed cloud layers made up of grains of minerals, the exact chemical composition and size of which varies with altitude.

> "Both planets will have complex, mixed cloud layers made up of grains of minerals"

For HD 209458 b, the top of the cloud layer is comprised of small grains, which grow larger and larger (up to about a millimetre across) as you descend into the deeper, hotter regions of the atmosphere. For HD 189733 b, the cloud particles are predicted to not grow quite as large, but to be made up of around 90 per cent solid iron at the cloud base.

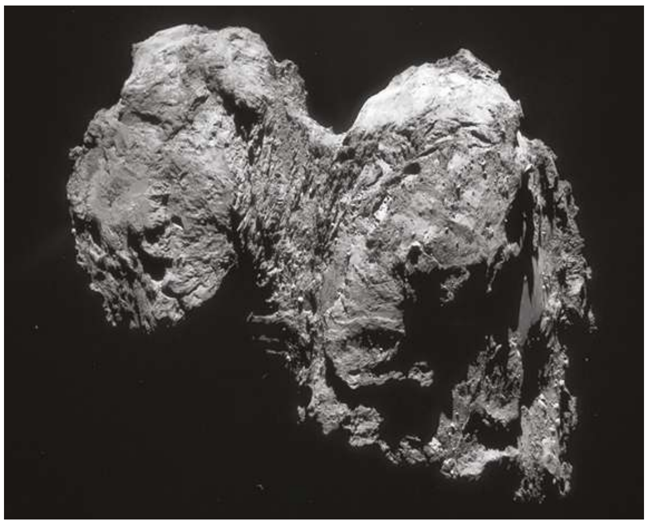
As with many aspects of exoplanets, it's only when you step back and pause to think what this actually means that it hits home just how alien these worlds really are. Their skies are filled not with white clouds of water droplets, but dark condensed grains of iron ore.

LEWIS DARTNELL is an astrobiologist at the University of Leicester and the author of *The Knowledge: How to Rebuild our World from Scratch* (www.the-knowledge.org)

LEWIS DARTNELL was reading… *The mineral clouds on HD 209458 b and HD189733 b* by Ch Helling et al
Read it online at http://arxiv.org/abs/1603.04022

Crystal ice betrays 67P's origins

The Rosetta comet may have formed closer to the Sun than first thought



▲ Comet 67P/Churyumov-Gerasimenko as seen by the Rosetta spacecraft's NavCam instrument

COMET 67P/CHURYUMOV-GERASIMENKO, the target of ESA's Rosetta mission, didn't originate on the cold outskirts of the Solar System but in a region closer to the Sun. Observations of the comet's coma suggest its icy heart is made from clathrates – a type of crystalline ice that's infused with gas.

"The protosolar nebula closer to the Sun experienced higher temperatures and more turbulence, where crystalline ices could form as the nebula cooled," says Drienn Luspay-Kuti from the Southwest Research Institute. "More pristine amorphous ices likely dominated the colder outskirts of the rotating disc of dust and gas that surrounds the core of a developing Solar System." **http://rosetta.esa.int**

FIRST LAUNCH FOR RUSSIAN SPACEPORT

THE FIRST ROCKET has been launched from the new Vostochny Cosmodrome in Russia. A Soyuz-2 rocket carrying three science satellites blasted off from the site at 02:01 UT on 28 April, after a 24-hour delay due to a minor technical fault.

Construction of the site, which is near Russia's Chinese border, began in 2012 as a venue for non-military rocket launches and an alternative to the Baikonur Cosmodrome in Kazakhstan. Although Russia will continue to launch from Baikonur, its space agency hopes to launch 10 rockets annually for the next few years from Vostochny and begin crewed mission launches to the International Space Station from 2023. **http://en.federalspace.ru**

The partly built spaceport will eventually host manned launches destined for the ISS

Looking back The Sky at Night

June 1966

Fifty years ago on 2 June 1966, *The Sky at Night* broadcast followed NASA's first soft landing on the Moon. The Surveyor 1 probe touched down in the Oceanus Procellarum and beamed back images of the lunar surface. But it predominantly carried engineering sensors, and it was the information they gathered that led to another six Surveyor probes, of which four successfully landed, paving the way for the Apollo missions.

Though a first for NASA, Surveyor 1 was actually the second probe to soft-land on the Moon, following the Soviet Luna 9 probe, which touched down on 3 January 1966. However, the Soviet space programme largely operated under a media blackout. As such the world's first images from the lunar surface had to be bootlegged by Jodrell Bank, who picked up the probe's signals, decoded them and send them on to the press.

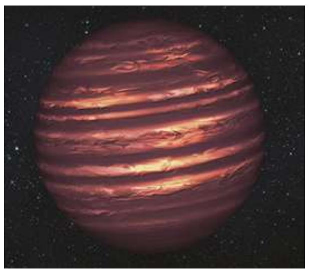
▲ Surveyor 1's shadow stands out starkly against the lunar surface

NEWS IN BRIEF

BROWN DWARFS MAY BE HIDING IN OUR GALAXY

A new analysis of brown dwarfs – bodies too large to be planets but too small to be stars – has found that they are spread unevenly across the sky. But these 'failed stars' should be uniformly distributed through our Galaxy, leading scientists to conclude that many are being missed in observations.

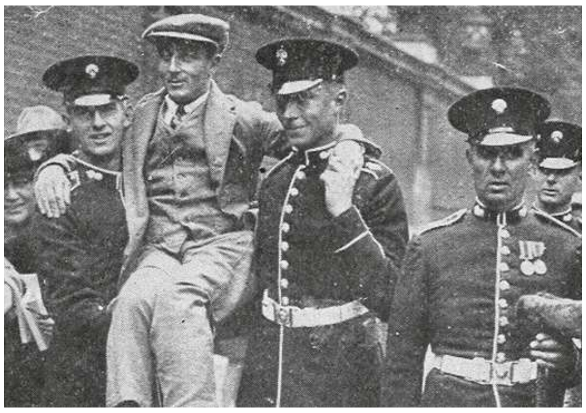
"It is quite possible that it's not just brown dwarfs are still hiding in the observational data, but also other objects with even smaller, planetary-like masses," says Ralf-Deiter Scholz from the Leibniz Institute for Astrophysics Potsdam. "So it's definitely worth it to take another deep look at both existing and future data."



25 YEARS OF NEAF

Now in its 25th year as the world's biggest astronomy show, the Northeast Astronomy Forum returned to New York on 9-10 April. Around 4,000 astronomers attended talks from the likes of the New Horizons team and eclipse expert Fred Espenak, and shopped with over 120 vendors, including *BBC Sky at Night Magazine.*

ESA/ROSETTA/NAVCAM, WWW.KREMLIN.RU, NASA, NASA/JPL-CALTECH



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What's on

Our pick of the best events from around the UK

PICK OF THE MONTH

▲ This year's Cheltenham Science Festival has plenty to offer space fans

Cheltenham Science Festival

Various venues, 7-12 June

Astronomers and space buffs are spoilt for choice at this year's Cheltenham Science Festival, with an impressive range of talks and events covering topics such as Tim Peake's mission on the ISS, the search for alien life and the majesty of the Sun.

'Planets On The Edge' looks at the potential discovery of Planet Nine, while 'The New Space Plane' reveals Virgin Galactic's project to take passengers beyond Earth's orbit. The UK Space Agency look back at Tim Peake's *Principia* mission, and will be opening its Space Dome to take guests on a virtual tour of the cosmos.

BBC Sky at Night Magazine columnist Lewis Dartnell explains how not to die on Mars, and *The Sky at Night* presenter Lucie Green takes a look at our host star.

Gravitational waves expert Sheila Rowan looks at the LIGO experiment and its role in one of the most important discoveries of our time. Comedian Ben Miller explores the chances of finding life beyond Earth, Nick Sayers reveals how to build your own Sun-capturing camera, and impressionist Jon Culshaw hosts an evening relaying his love of all things cosmic. For full details of all the events and booking information, visit **www.cheltenhamfestivals.com/science**

BEHIND THE SCENES

THE SKY AT NIGHT IN JUNE

BBC Four, **12 June,** 10pm (first repeat BBC Four, **16 June**, 7.30pm)*

The Whirlpool Galaxy is a favourite deep-sky target among amateurs

SUMMER SKY OBSERVING

This month the *Sky at Night* team turn their attention to observing in the summer sky. The June episode sees Chris and Maggie show how large deep-sky objects can be analysed using different magnifications and wavelengths of light to reveal their cosmic secrets.

Check www.bbc.co.uk/skyatnight for subsequent repeat times

MCPHERSONSTEVENS.COM, © BOEING, DR MIKE LEGGETT, NICK HART, ISTOCK

Above and Beyond

National Maritime Museum, Greenwich, from 27 May

This programme of interactive exhibitions and immersive simulations celebrates the past, present and future of spaceflight. Take an elevator ride out to the edge of space and look back on Earth, or travel to Mars to see how your body would cope on a long journey to the Red Planet. For the full programme and booking information, go online.
www.rmg.co.uk/see-do/above-and-beyond-season

Space Stations: From Salyut to the ISS

Nene Valley Astronomical Society, Sudborough, Northants, 2 June, 8pm

Dr Mike Leggett looks at the history of humanity's journey into space via the outposts situated in Earth's orbit, starting from the Russian Salyut and progressing through to Mir and the International Space Station. The talk will also explore the various applications of a permanent space base and what future space infrastructure might look like. Admission is £3, including refreshments.
http://neneastro.org.uk

Astronomical Imaging Under City Lights

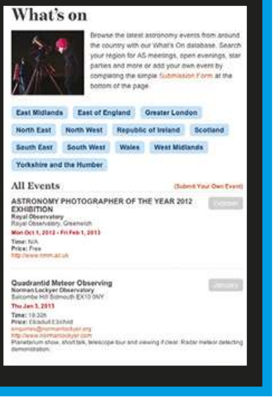
Cardiff University, Queens Buildings, Cardiff, 23 June, 7.30pm

Nick Hart is an astrophotographer and member of Cardiff Astronomical Society. In this talk on behalf of CAS, he reveals how deep-sky imaging is possible even under the harsh light pollution of big cities like his.
www.cardiff-astronomical-society.co.uk

MORE LISTINGS ONLINE

Visit our website at **www.skyatnightmagazine.com/whats-on** for the full list of this month's events from around the country.

To ensure that your talks, observing evenings and star parties are included, please submit your event by filling in the submission form at the bottom of the page.



What's on

Browse the latest astronomy events from around the country with our What's On database. Search your region for AS meetings, open evenings, star parties and more or add your own event by completing the simple Submission Form at the bottom of the page.

East Midlands | East of England | Greater London | North East | North West | Republic of Ireland | Scotland | South East | South West | Wales | West Midlands | Yorkshire and the Humber

All Events (Submit Your Own Event)

ASTRONOMY PHOTOGRAPHER OF THE YEAR 2012 EXHIBITION
Royal Observatory
Royal Observatory, Greenwich
Mon Oct 1, 2012 - Fri Feb 1, 2013
Time: N/A
Price: Free

Quadrantid Meteor Observing
Norman Lockyer Observatory
Salcombe Hill Sidmouth EX10 0NY
Thu Jan 3, 2013
Planetarium show, short talk, telescope tour and viewing if clear. Radar meteor detecting demonstration.

PINT OF SCIENCE FESTIVAL 23-25 MAY 2016

www.pintofscience.co.uk
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A PASSION FOR SPACE

with Maggie Aderin-Pocock

The Sky at Night presenter reflects on the myriad mysteries of the Solar System's innermost planet

Mercury is grey and cratered like our Moon, but that's where the similarities end

ISTOCK

On 9 May Mercury, the smallest planet in the Solar System, appeared to pass across the face of the Sun in a transit. This was a rare event: there are only 13 every century. But what do we know of this planet, which sits closest to the Sun?

At first glance Mercury appears very similar to the Moon: pale grey and covered in craters. Its diameter is just 30 per cent larger than our lunar neighbour, but that is where the similarities end.

Mercury has the shortest orbit of all the planets in the Solar System, completing each loop in just 88 days. However, the planet spins so slowly that a Mercurian day lasts two Mercurian years. Its rotation rate and proximity to the Sun mean that the planet experiences extremes of temperature, varying from as high as 450°C to lows of –180°C. Yet surprisingly, considering temperatures can peak so high, there are areas on the surface of Mercury that never get above 0°C.

The planet's orbit, as well as being the shortest, is also the most elliptical of any in the Solar System – bringing Mercury just 46 million km from the Sun at its closest approach and 70 million km at its farthest. But Mercury has virtually no orbital tilt and is hence bereft of seasons. There is, however, a thin atmosphere, mainly made up of oxygen, sodium and hydrogen. As the planet sits so close to the Sun it means that gases in this atmosphere can be sheared off by the solar wind, giving Mercury a tail visible to professional telescopes and observatories in space.

Interior enigma

The internal structure of Mercury has resulted in a lot of speculation into how the planet could have been formed. Its ratio of core to mantle seems too big to have been formed along conventional accretion and merger lines. Consequently, theories of a collision with a small, fast projectile that removed some of Mercury's mantle have been suggested. But observations of the planet taken by the Messenger spacecraft, a mission that came to an abrupt end on 30 April after it smashed into the planet at 14,000km/h, revealed that volatiles like potassium and sulphur were present in the mantle. This didn't add up with the theory of a collision removing some of the mantle; such a collision would have greatly elevated the temperature of Mercury causing these volatiles to be lost.

In light of these results the theory of Mercury's conception is being updated towards a new model. This outline involves a more gentle collision with a much bigger object like Venus, and it could help to explain the presence of the volatiles in Mercury's mantle and why Venus's mantle is larger than expected too.

It's theories like this that the new joint European and Japanese mission called BepiColumbo will seek to answer. It is due to launch in 2017 and reach Mercury in 2024. Hopefully it will shed new light on the planet's elusive past and some of it more exotic characteristics. Ⓢ

Maggie Aderin-Pocock is a space scientist and co-presenter of *The Sky at Night*

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JON CULSHAW'S

EXOPLANET EXCURSIONS

Jon muses on how ancient Methuselah is likely to share the same fate as Pioneer 10

Arriving at Methuselah, as the planet orbiting pulsar PSR B1620-026 is unofficially known, brought feelings of awestruck nausea from attempting to take in its 12.7 billion year age. Now, after steering the Perihelion closer to the planet, we're resting on an orbiting Deimos-sized moon at a steady hover. There's a welcome calmness here, with the parent stars bringing a glow not unlike that of a full Moon on Earth.

It's sobering to contemplate what this Jupiter-sized planet has witnessed and overcome. In its early days it orbited a star that may have been similar to the Sun. A tempestuous chapter must have followed, when the planetary system drifted into the core of M4 – that's where PSR B1620-026 is, by the way – and violent gravitational confrontations eventually ejected the original Sun-like star. Methuselah then began the second act of its life, having been captured into orbit around a neutron star and its binary companion. The neutron star's companion ballooned to red giant status, its outer layers accreting onto the neutron star, whipping it up to be regenerated into a pulsar.

It appears that Methuselah possesses a powerful magnetic field. Looking up towards the planet's north pole it's plain to see the result of this magnetic field interacting with the pulsar, in the form of the most intensely vivid auroral display.

These Methuselan aurorae look to be composed of opaque light – almost too dazzling to observe directly. Bands of colour beam, swirl and dance around the Methuselan auroral oval, like a pulsing loop of the ZX Spectrum logo.

Methuselah's dramatic past brings to mind the Pioneer 10 spacecraft, launched for Jupiter in 1972. Soon after Pioneer 10's arrival it was ejected from the Solar System by Jupiter's immense gravity and left to drift silently though interstellar space, bearing that famous greetings plaque from humankind. Pioneer 10 will outlive Earth in all probability, preserved for billions of years in the pure, vast, emptiness of interstellar space.

This planet could go through yet more gravitational tussles in its future, which could eject it from M4 altogether. The planet will then enter the next stage of its existence, sent like Pioneer 10 to drift through interstellar space for untold eras of the deepest time – possibly until the heat death of the Universe itself.

Glancing around the vicinity of the moon, there appear to be outcrops which are oddly jagged and artificial in shape; it's tricky to imagine that they're naturally occurring at all. They look more like ancient, faded remnants of a long-past civilisation. There are also irregular indentations in the beige-grey landscape. Perhaps this region has been visited before my arrival – could this ebullient aurora be one of the six million wonders of the Milky Way, attracting visitors from all over the Galaxy?

Contemplating the sense of infinity Methuselah exudes, I can't help muse about the Genesis Planet in the voice of Tom Baker. "Surviving violent gravity and interstellar chapters beyond imagination," I think to myself. "Methuselah, the Genesis Planet, here among the Messier stars, ready to outsit eternity... It's indomitable. Indomitable."

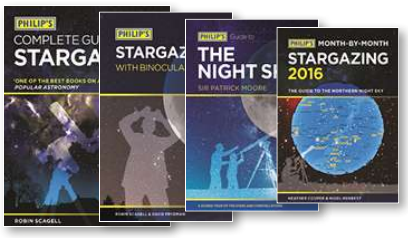
Jon Culshaw is a comedian, impressionist and guest on *The Sky at Night*

MAIN ILLUSTRATION: MARK GARLICK, SPACECRAFT: PAUL WOOTTON, PHOTO: EMMA SAMMS

This month's top prize: four Philip's books

The 'Message of the Month' writer will receive four top titles courtesy of astronomy publisher Philips: Robin Scagell's *Complete Guide to Stargazing*, Sir Patrick Moore's *The Night Sky*, Robin Scagell and David Frydman's *Stargazing with Binoculars* and Heather Couper and Nigel Henbest's *Stargazing 2016*

PHILIP'S



SOCIAL MEDIA

WHAT YOU'VE BEEN SAYING ON TWITTER AND FACEBOOK

Have your say at **twitter.com/skyatnightmag** and **facebook.com/skyatnightmagazine**

@skyatnightmag asked: What got you into astronomy?

Michael Nicholls Seeing noctilucent clouds for the first time from Scotland on holiday in the 1970s when I was about 6 or 7 years old.

@roasty11 Comet watching back in the early 80's laying on the roof of my neighbours shed with binoculars and my big brother.

@Damien_Wev I was inspired by the Stargazing Live show in 2013. I am now a member of a local society and hooked on astrophotography.

Interactive

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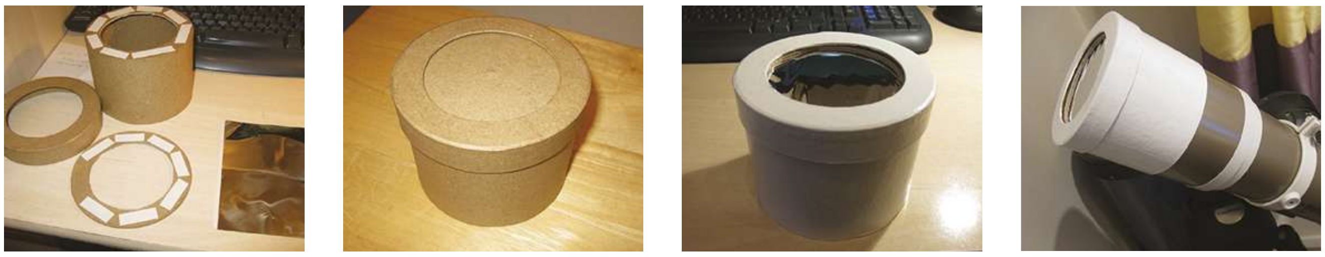
Email us at inbox@skyatnightmagazine.com

MESSAGE OF THE MONTH

The home-made solar filter that's boxing clever



▲ Steve transformed a round box into a perfect frame for a solar filter – once painted it looks like part of the scope

I have a Sky-Watcher 80ED Pro telescope and decided to make a solar filter for it out of Baader AstroSolar Safety Film so that I could view and image the Sun. Before starting, I went to my local hobby and craft shop to see if it had anything that might make it easier to fit the filter onto the scope. There I found a round cardboard box with a framed lid that was exactly the right size to fit over the front of my 80ED! I bought one and some double-sided tape, and was ready for the build. First I cut a circle out of the lid insert with a knife and used double-sided tape to stick the filter and top lid together. Then I cut another circle out of the bottom of the box and stuck the lid on. A finishing coat of white paint matched the filter to the 80ED perfectly! Hobby and craft shops often have a variety of frame boxes in various shapes and sizes, so a solar filter like this could be made for a range of telescope sizes.

Steve Macdonald, Bolton

A moment of genius, Steve! What a clever, time-saving workaround. ***– Ed***

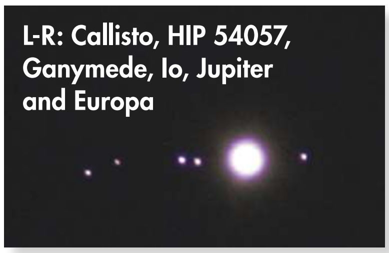
Learning the lingo

I'm a new subscriber who's confused by a lot of the technical terminology. You'll probably smile, but it was only by accident that I found out what UT was and I'm still not sure about AU. I eagerly read a review of a beginner's telescope but there were types of mounting, eyepieces and telescopes that I'm not sure about.

Tim Inchley, via email

Visit our online dictionary at www.skyatnightmagazine.com/dictionary, where AU, UT, Newtonian, Dobsonian and many more esoteric terms that are common to our hobby are explained! ***– Ed***

An interloper at Jupiter



L-R: Callisto, HIP 54057, Ganymede, Io, Jupiter and Europa

At about 20:50 BST on 13 April I was trying out my 10-inch reflector on a new Dobsonian mount in my back garden and looked at Jupiter. Astonishingly, it appeared to have acquired a fifth large satellite. I rushed for my camera, a Canon EOS 20Da DSLR, and attached it to my 5-inch refractor. I took a number of shots between one second and four seconds at 1600 ISO; this one was a two-second exposure. Obviously the 'fifth satellite' is an intervening star, the mag. +7.5 HIP 54057.

Tony Titchener, Seaford, Sussex

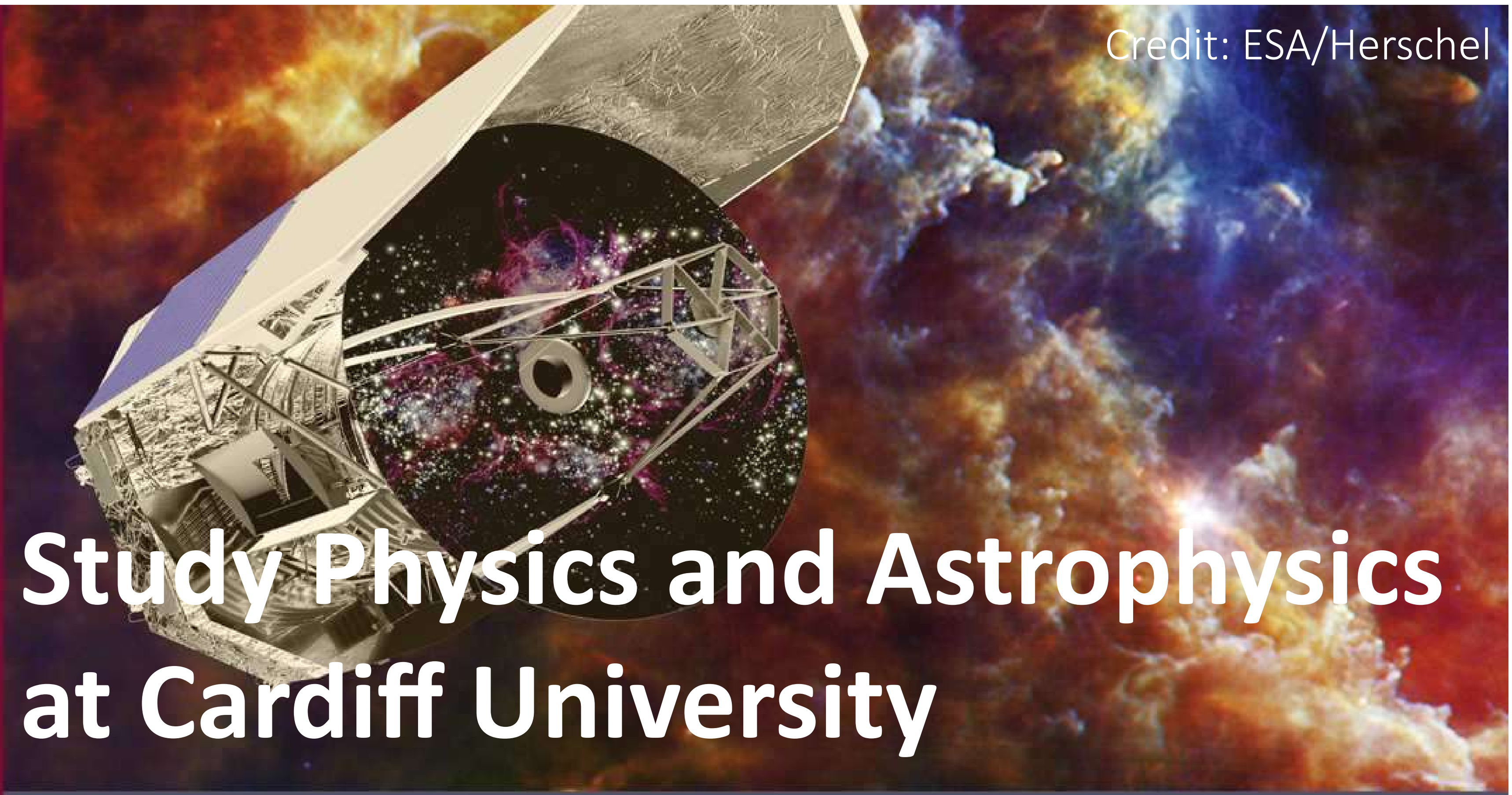
Great spot Tony! Jupiter is such a fascinating system to observe, there's always something going on. ***– Ed***

Flummoxed by a flag

I'm 65 and new to this fascinating hobby. I have a question to ask on behalf of myself and the magic club I belong to: with all these fantastic telescopes showing us photographs of distant planets millions of miles away why has nobody taken a photograph of the flag left on the Moon?

Peter Loft, Hull

No telescope can yet reveal detail that small on the Moon, Peter, but NASA's Lunar Reconnaissance Orbiter, which circles the Moon, flew a special low orbit to capture the Apollo landing sites. And one of the images (http://bit.ly/apollo17flag) does show Apollo 17's flag! ***– Ed***



Credit: ESA/Herschel

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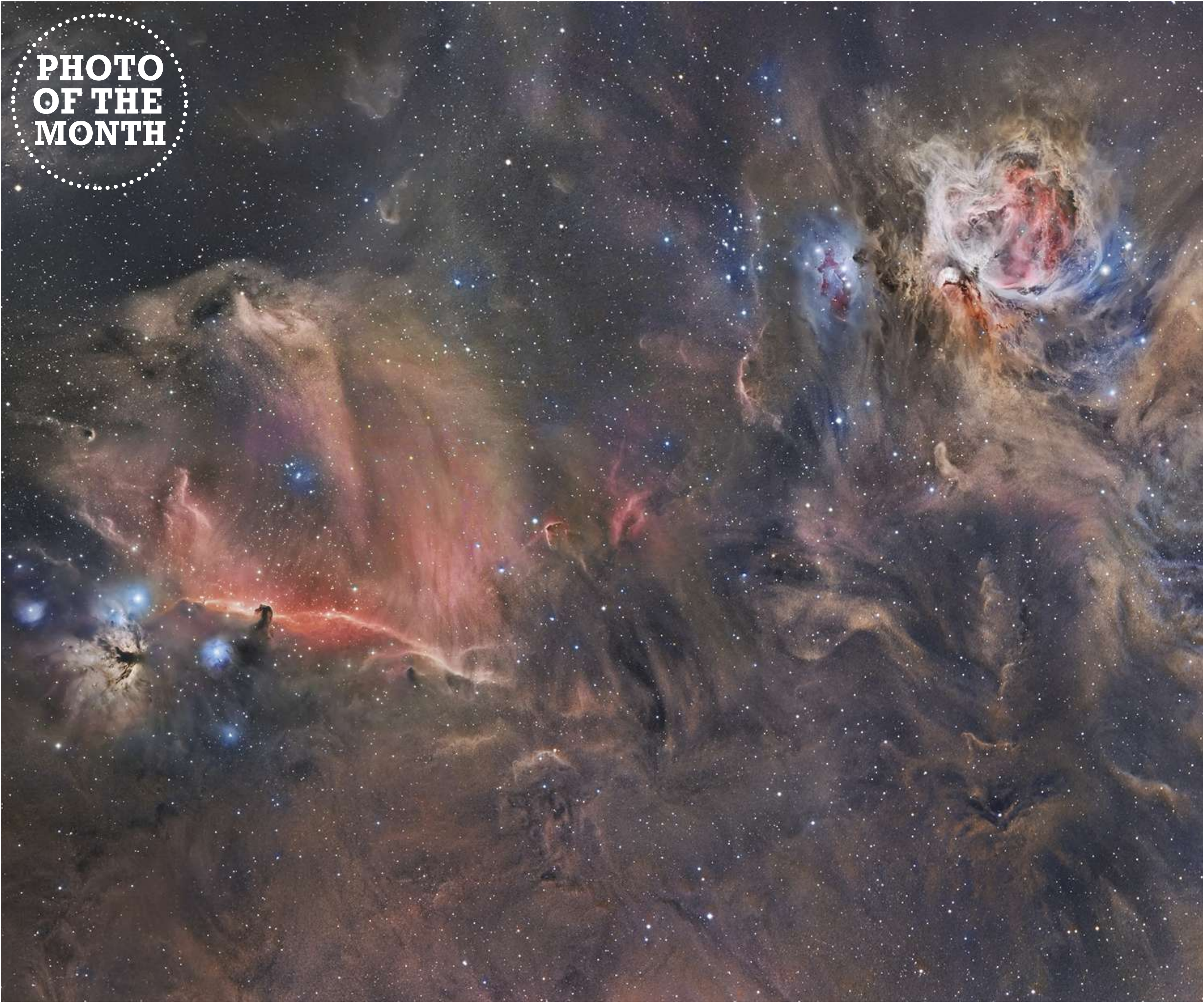


▲ Orion mosaic

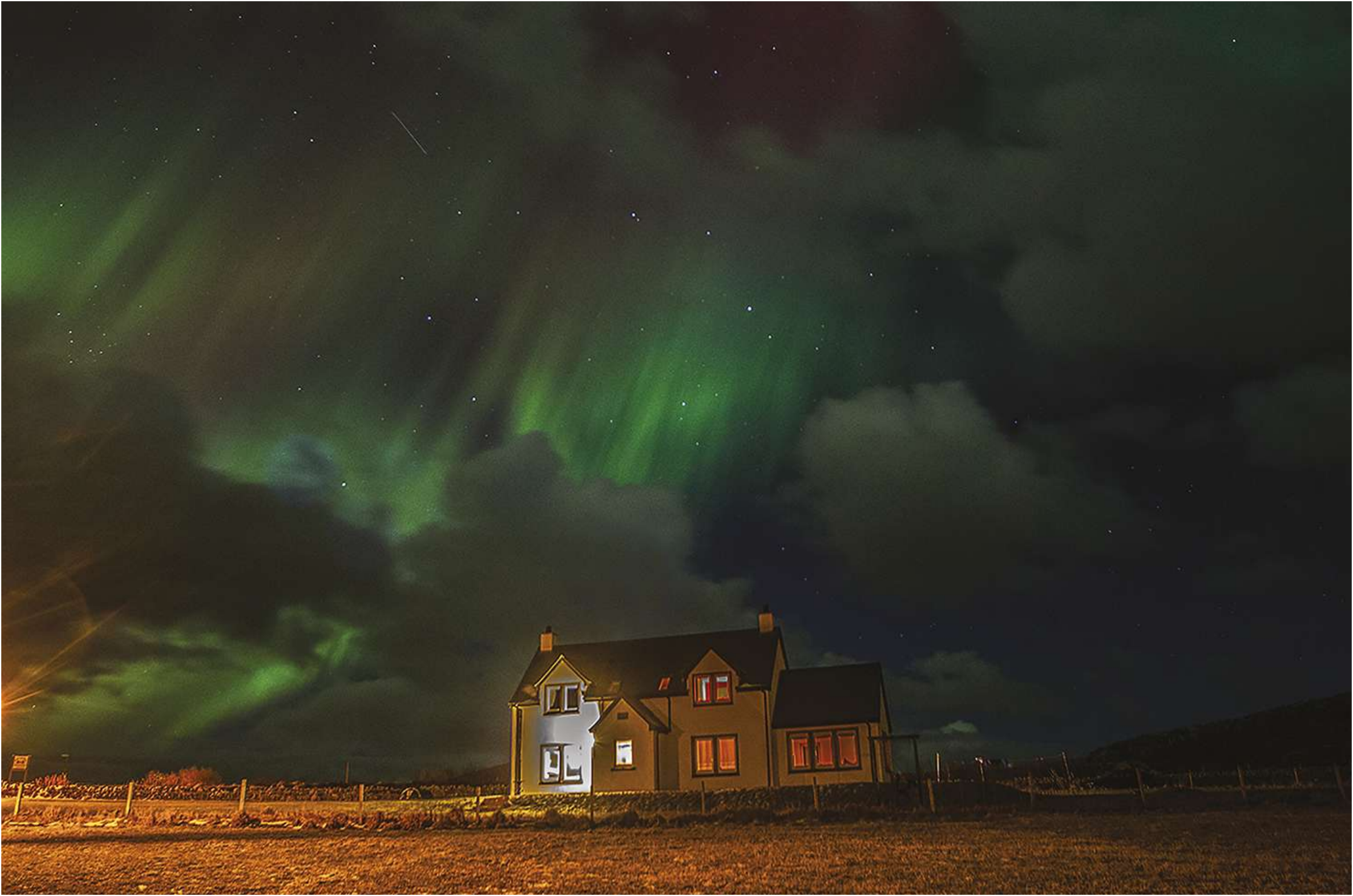
PAUL C SWIFT, VALENCIA, SPAIN, 20 FEBRUARY 2016

Paul says: "I set out to produce a portrait of the Orion Nebula, including the space bridging it and the Horsehead Nebula. My aim was to use the benefits of fast optics in combination with a long narrowband exposure to produce fine detail. The image is made up of multiple panels in mosaic and contains around 70 hours of exposure shot over a period of two months."

Equipment: Starlight Xpress SXVR-H18 CCD camera, Vixen VSD 4-inch astrograph, Paramount MX mount.

***BBC Sky at Night Magazine* says:** "This crystal clear, pin sharp image has something of a psychedelic feel to it, as the red wisps of gas, swirls of black dust and blue glow of young stars combine to produce a colourful, chaotic image. An added bonus is the fact that Paul has captured the Horsehead and Orion Nebulae in the same shot."

About Paul: "Having had a background in the arts and worked professionally as a cinematographer and lighting cameraman, astrophotography made for a natural change in focus. I had always wanted to turn my camera to the skies, and a move from London to Valencia presented me with the perfect opportunity to do just that."

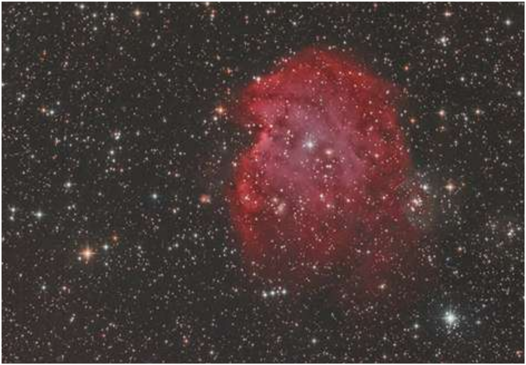


▲ Aurora over Bae Seren

ANDY WALKER, SUTHERLAND,
6 MARCH 2016

Andy says: "I knew the aurora was forecast to be strong but forecasts rarely come to fruition. However on this occasion it did – big time! I was also lucky enough to capture a shooting star passing overhead."

Equipment: Canon EOS 70D DSLR camera, Sigma 15-30mm EX DG lens.

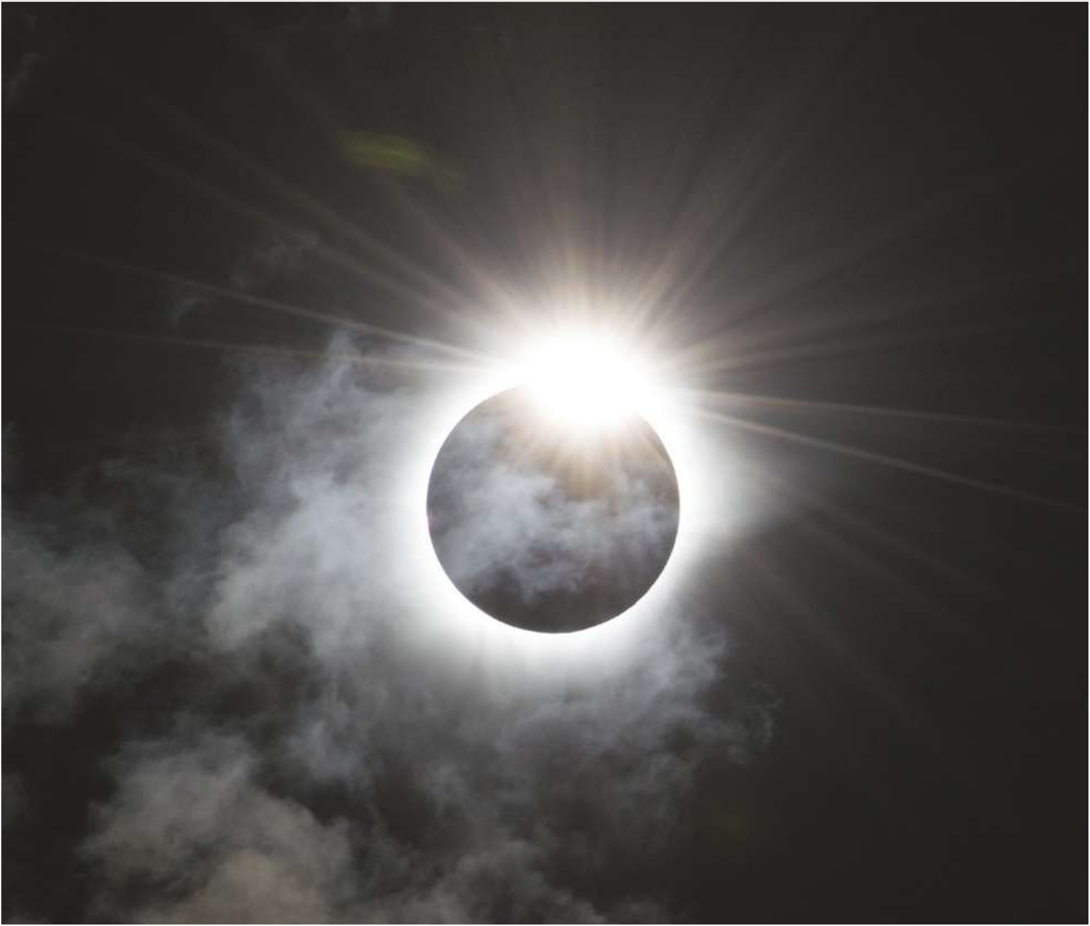


▲ The Monkey Head Nebula

CRAIG JAMESON, EDINBURGH,
10 FEBRUARY 2016

Craig says: "This had been on my list to do for ages. I rotated the image to make the monkey head stand out more to the eye. I always try and do a minimal amount of processing to retain a natural look."

Equipment: QHY8 Pro CCD camera, Altair Astro 8-inch Imaging Newtonian.

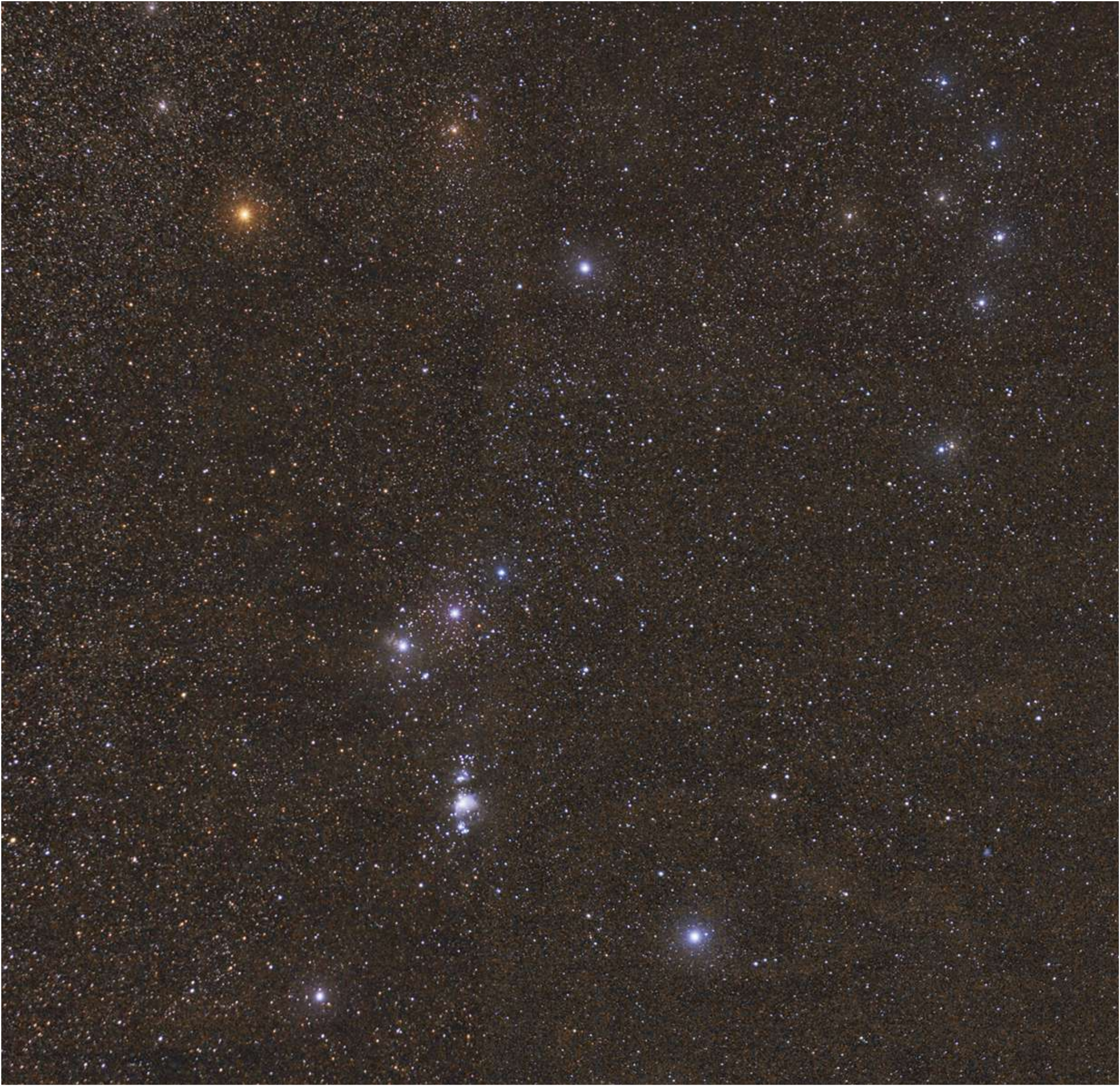


▲ Total solar eclipse

MELANIE THORNE, INDONESIA, 9 MARCH 2016

Melanie says: "I went to the island of Tidore to view the eclipse as part of a group. When I saw the image on my screen I could not believe it. This was my favourite shot because the cloud makes the whole scene very atmospheric."

Equipment: Nikon D3200 DSLR camera, 70-300mm lens, homemade Baader solar filter.



◀ Orion

BILL MCSORLEY, DERBYSHIRE DALES, 10 FEBRUARY 2016

Bill says: "This image was taken while on a short break in the Dales. I managed to image the main body of Orion and afterwards I thought I ought to have also included his shield and arm. Fortunately we had a second clear night and I managed to capture the extra data needed."

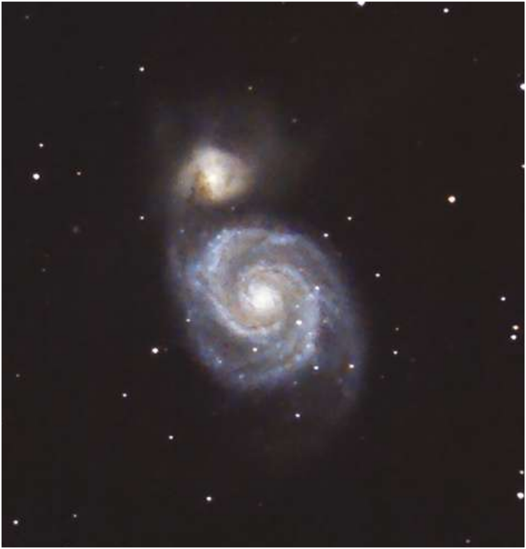
Equipment: Unmodified Canon EOS 1000D DSLR camera, 18-55mm lens, Sky-Watcher Star Adventurer mount.

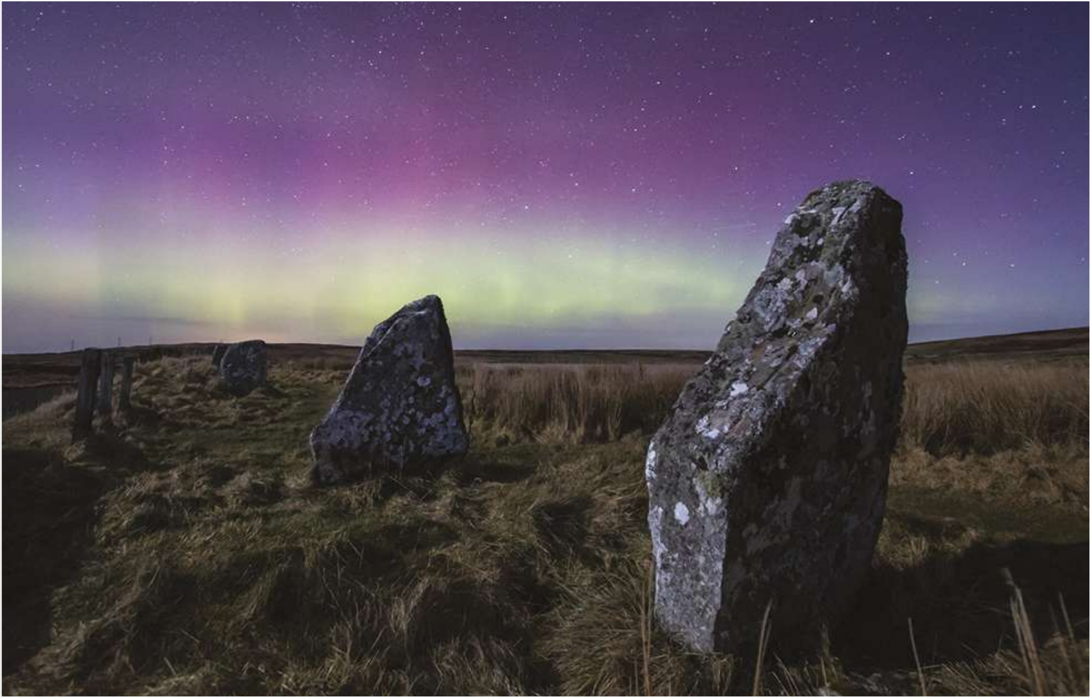
▼ The Whirlpool Galaxy

ALISON BOSSAERT, KIRKBY-IN-ASHFIELD, 11 MARCH 2016

Alison says: "I always make a list of targets for the coming month, and I chose the Whirlpool Galaxy as it was a high target. The object was nicely centered so I set the remote control to take about 20 shots at two minutes and ISO 800."

Equipment: Canon EOS 5D Mk II DSLR camera, Sky-Watcher Explorer 200P-DS telescope.



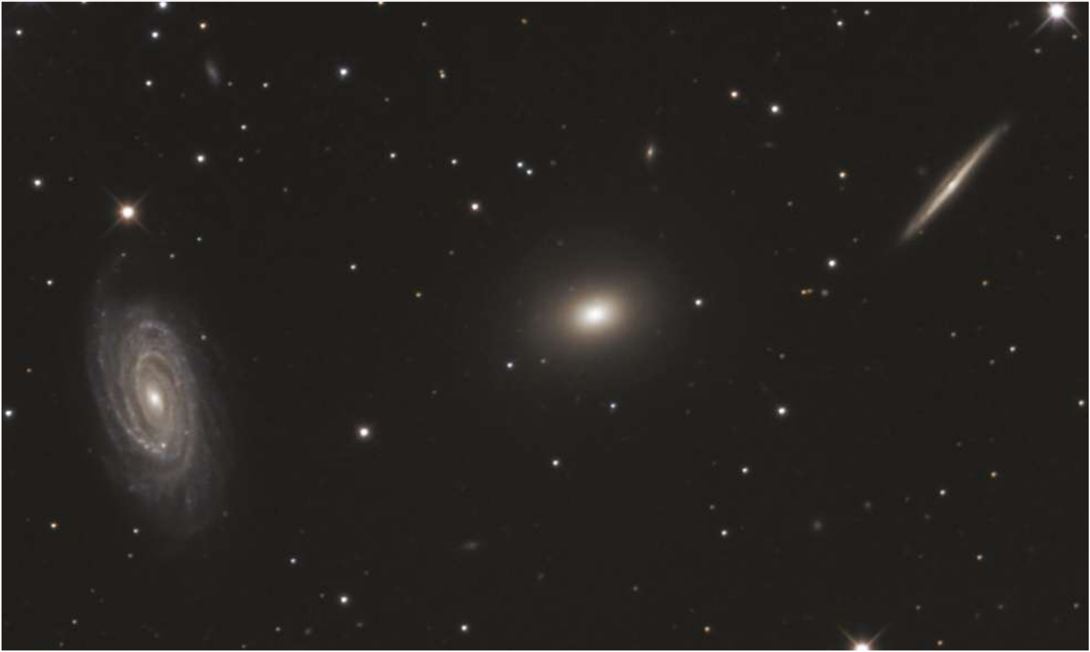


▲ Achavanich aurora

GORDON MACKIE, ACHAVANICH STANDING STONES, CAITHNESS, 14 MARCH 2016

Gordon says: "I worked out that light from the first quarter Moon would gently illuminate the foreground stones, and the aurora made an appearance just as I arrived to set up. I found myself imagining the people who put the stones in position millennia ago, and how they may have enjoyed a similar view of the night sky."

Equipment: Canon EOS 760D DSLR camera, Sigma 10-20mm lens.



▲ The Draco Trio

DAN CROWSON, NEW MEXICO, US,
19 MARCH 2016

Dan says: "The Draco Trio is one of my favorite objects to image. Finally having acquired a long focal length telescope, this is my deepest image so far, taken over seven nights."

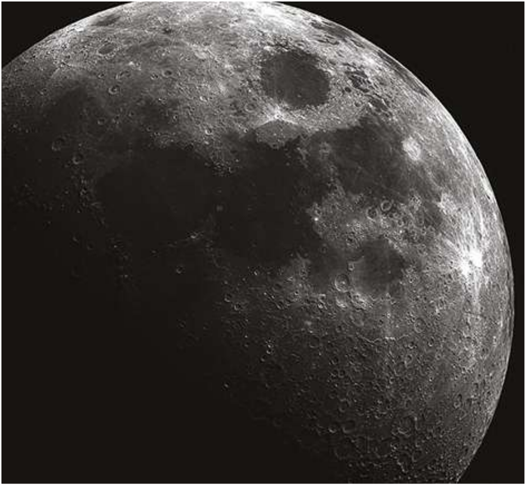
Equipment: SBIG STF-8300M CCD camera, Astro-Tech 12-inch Ritchey-Chrétien telescope.

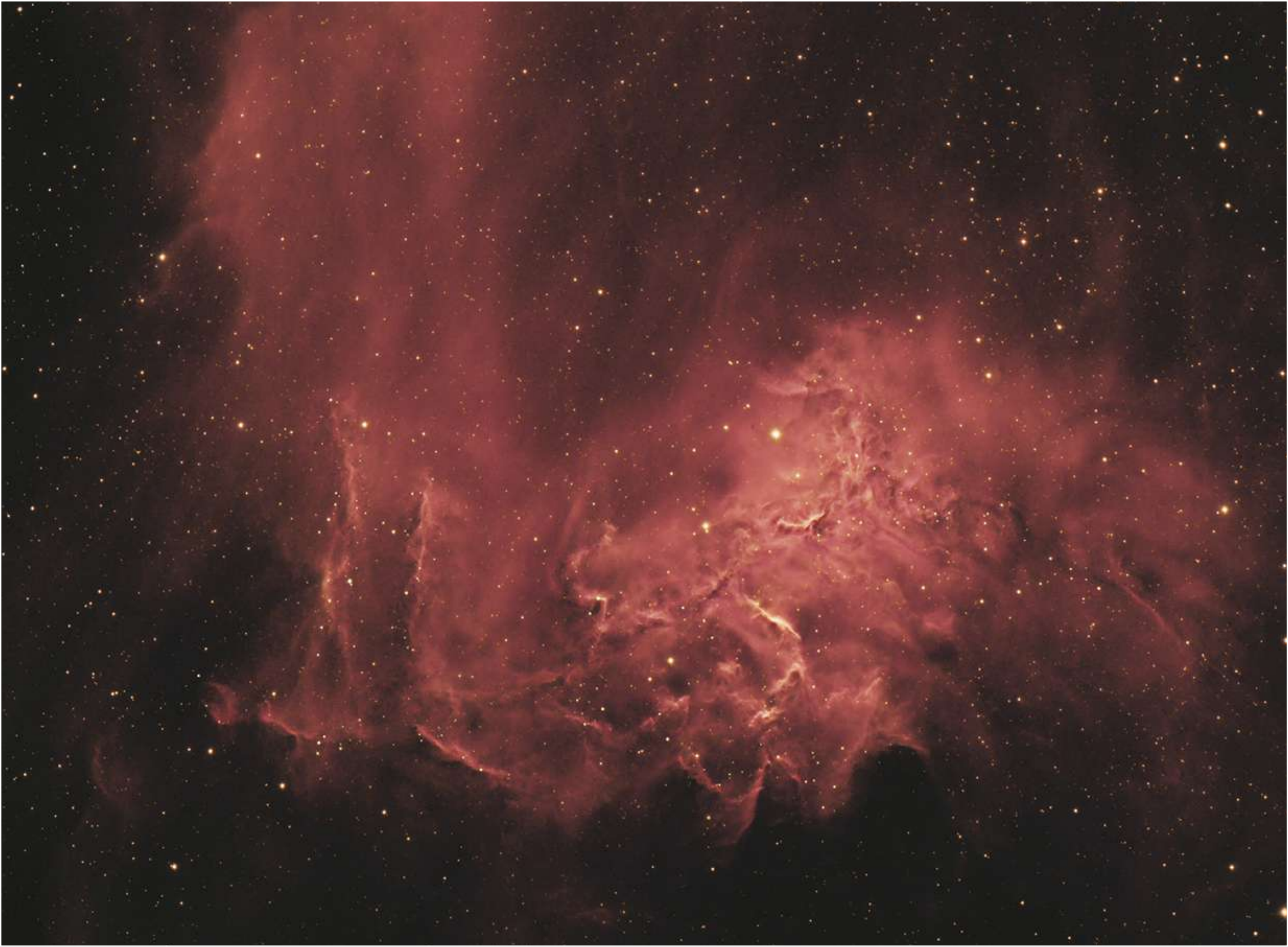
▼ The Moon

DANIEL CAMERON, AYR, 16 MARCH 2016

Daniel says: "This image was produced using a monochrome video of the Moon. I then processed the video in Autostakkert, which allowed me to split it into individual frames and stack the best ones to produce a sharper image."

Equipment: ZWO ASI174MM CMOS camera, Sky-Watcher Evostar 120mm refractor, NEQ6 mount.





◀ Flaming Star Nebula

PETER JENKINS,
KIRKBY-IN-ASHFIELD,
7 MARCH 2016

Peter says: "I was really pleased with the detail in this image, the Ha showing red and SII providing the yellow highlights. I think the photo shows it to be a region of fierce activity that has a very threatening appearance."

Equipment: QHY5-II mono camera, Atik 383L+ mono CCD camera, Officina Stellare HiPer apo 4.5-inch refractor, Sky-Watcher NEQ6 Pro SynScan mount.

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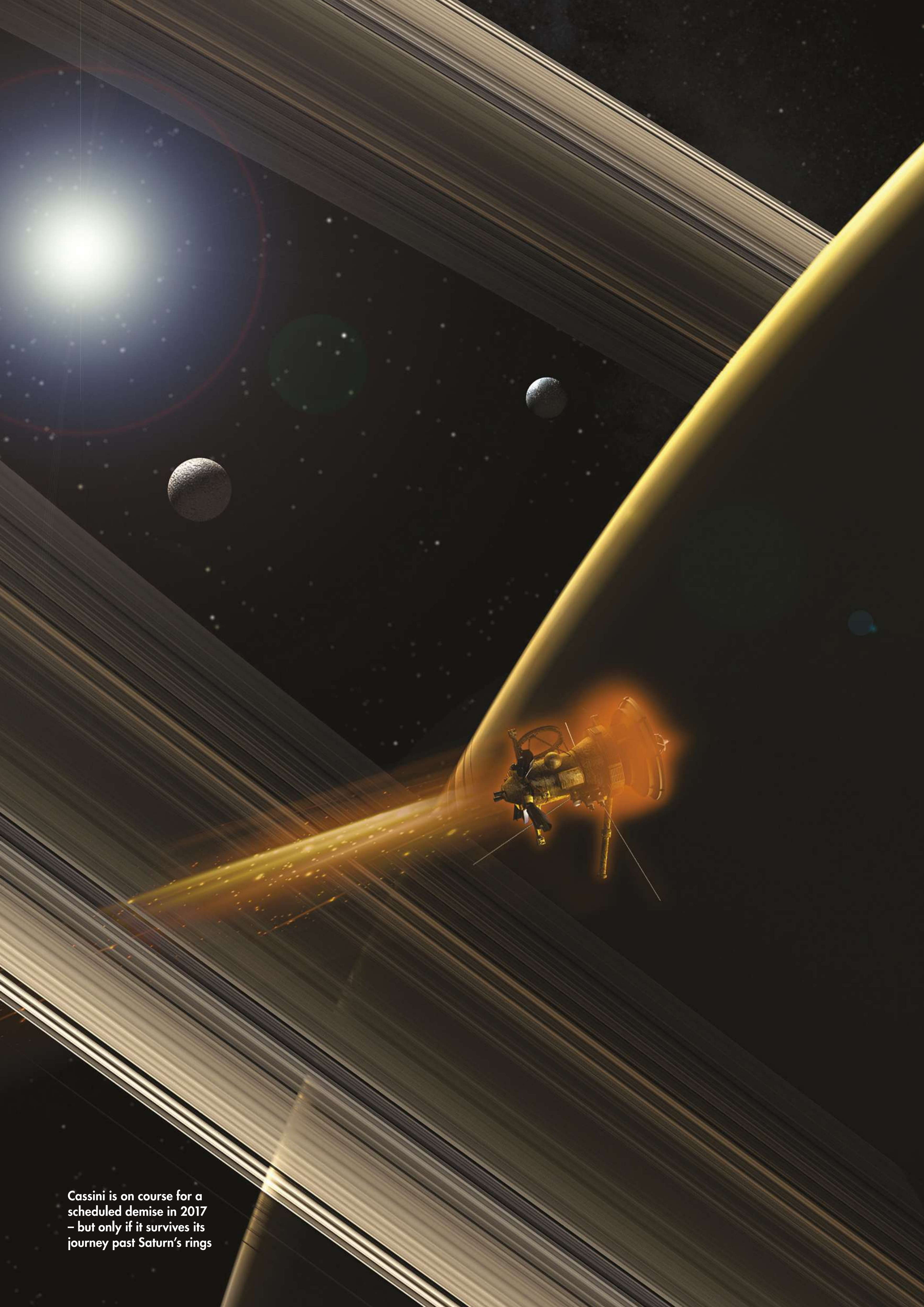

Cassini is on course for a scheduled demise in 2017 – but only if it survives its journey past Saturn's rings

Cassini's FINAL ADVENTURE

Will Gater investigates how the probe that has given us unprecedented views of Saturn will finally meet its end

After a journey of many billions of kilometres that's seen it discover new worlds and revolutionise our understanding of numerous others, NASA's 13-year-long reconnoitre of the Ringed Planet, Saturn, is coming to an end. Come September 2017, the stream of images and scientific data being sent back by the Cassini spacecraft will abruptly cease, and a mission that's enthralled and amazed in equal measure will draw to a close.

It's a conclusion that's been in the planning for some time. But for those working on the mission – and the scores of the spacecraft's fans around the world – it'll nevertheless be a difficult moment to take in. "I envision Cassini like a real person, even like one of my children," says the mission's project scientist Dr Linda Spilker of NASA's Jet Propulsion Laboratory (JPL). "I have been part of her life since her birth and launch, and happily watching like a proud parent as she took her first steps in the Saturn system. The day I have to say goodbye to her will be a very sad one for me. It will be like losing a best friend, someone I have come to know inside and out, someone I will miss. I will definitely shed a tear."

Cassini's end will come when the trajectory the NASA team set it on next year causes the spacecraft to eventually crash into the pastel Saturnian cloud tops – something that needs to be done to protect some of the moons that orbit the planet. "Cassini has shown that Enceladus and Titan have the potential to contain habitable (or at least 'pre-biotic') environments," explains the mission's program manager Dr Earl Maize, also at JPL. "Planetary protection requirements dictate that we make every effort to dispose of the spacecraft where it cannot contaminate these moons. Entry into Saturn's atmosphere guarantees the destruction of any microbes hardy enough to survive Cassini's long journey."

ABOUT THE WRITER

Will Gater is an astronomy journalist, author and astrophotographer. Follow him on Twitter: @willgater

One last hurrah

Before this fiery denouement, though, Cassini and the mission's teams back on Earth have much work to do. In fact the spacecraft's swansong at Saturn should produce a wealth of new insights into the workings of the ringed world. That's because this time next year Cassini will be flying into uncharted territory; in the months before it impacts Saturn, the spacecraft will execute a series of 22 final orbits that will take it between the rings of the planet and the gas giant's atmosphere.

"Once in this set of orbits our key science goals include detailed measurements of Saturn's gravity ▸

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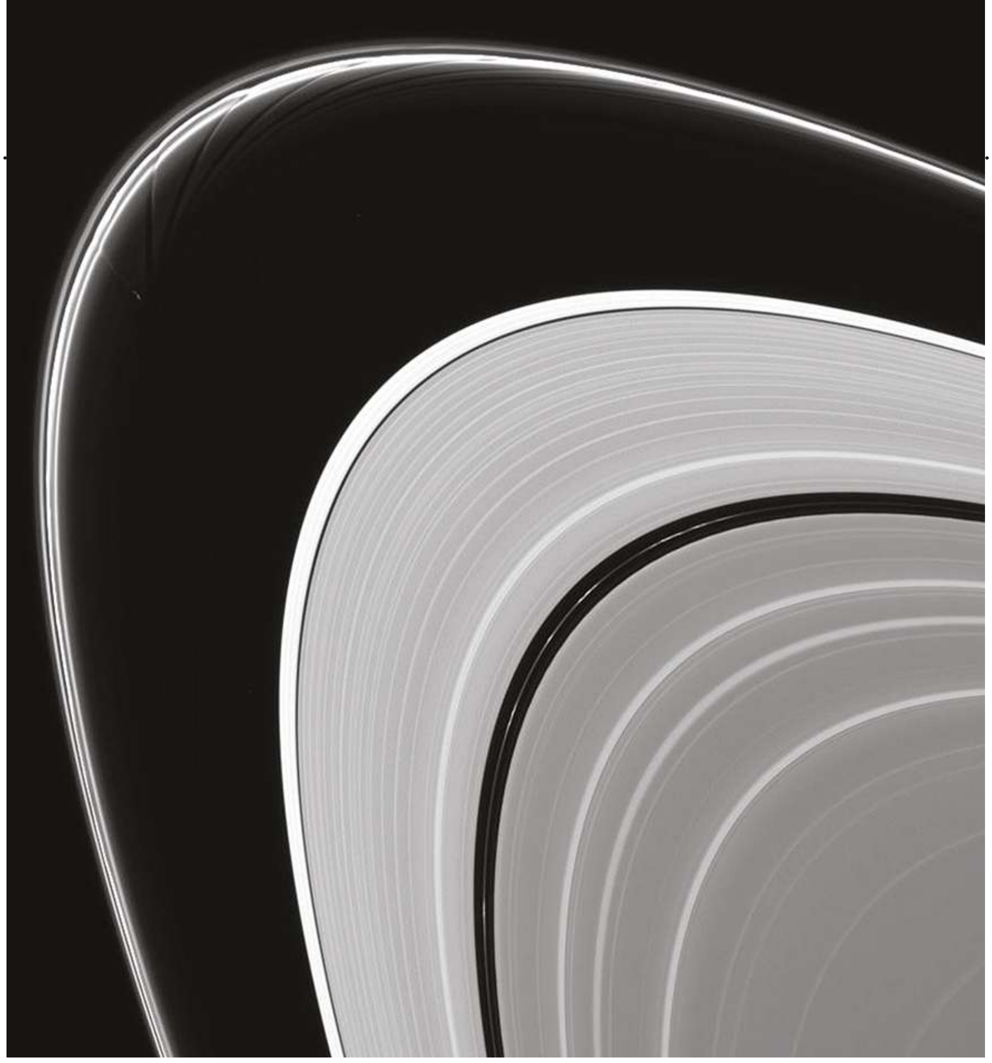
▸ and magnetic fields to understand the internal structure of the planet," says Spilker. "These orbits provide a new window on what is happening inside Saturn because we are so close to the planet. We will also directly sniff the upper atmosphere of Saturn to determine its composition, and taste some of the main ring particles to find out what they are made of besides water ice. The composition of the non-icy material is completely unknown and it is exciting to think about solving this mystery."

Just as they have done since the mission arrived at Saturn, Cassini's cameras will document the spacecraft's extraordinary final months. Cassini's path around Saturn at this time will, for example, enable it to capture spectacular high-resolution images of the planet's exquisite ring system.

"Only on rare occasions have we managed to take images of the rings with a resolution better than 1km per pixel," says Cassini imaging team member Prof Carl Murray of Queen Mary University of London. "But during the final orbits we should be able to do that on a regular basis."

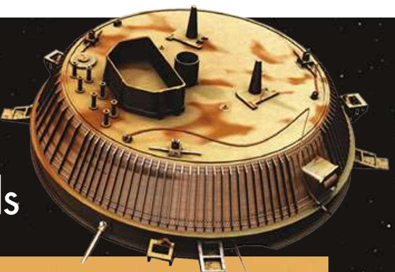
One target Murray hopes to see in detail in the coming months is one of Saturn's most enigmatic

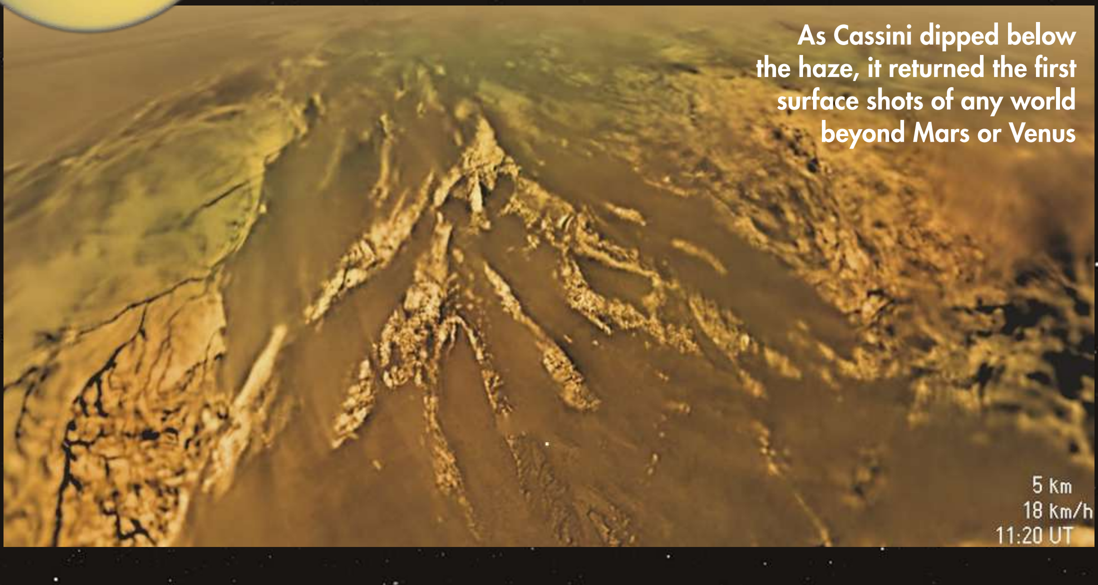


▲ The F ring's dynamism is revealed in this image; the moon Prometheus can be seen in the top left, creating gores and streamers in the ring as it passes

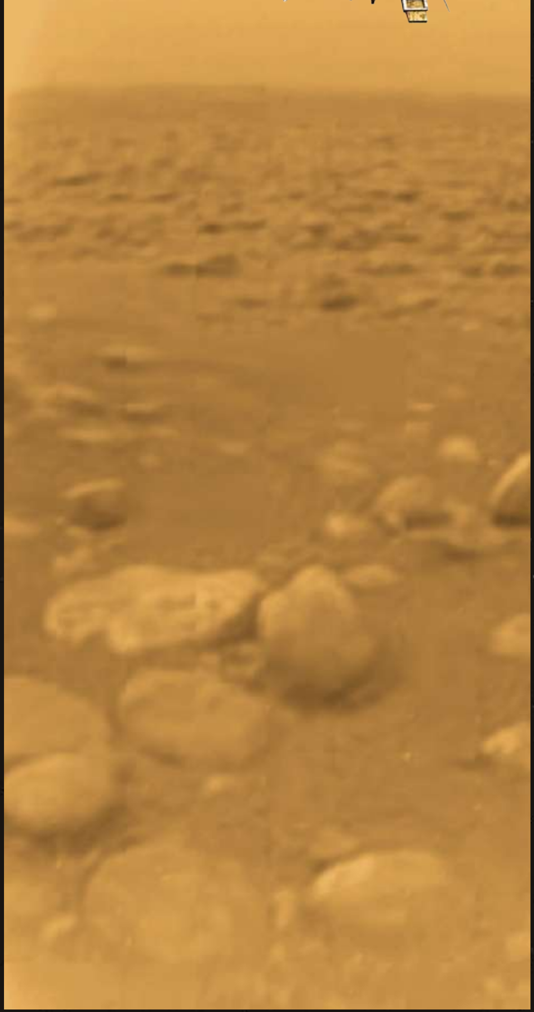
UNCOVERING TITAN

Huygens gave us our first glimpse below the moon's clouds





As Cassini dipped below the haze, it returned the first surface shots of any world beyond Mars or Venus



▲ When Huygens landed it retuned this now iconic shot of icy pebbles on Titan's surface

Give that Cassini has spent 13 years exploring Saturn, it's easy to forget that one of the mission's highlights occurred just months after it arrived at the Ringed Planet. On Christmas Day 2004, the Huygens lander successfully separated from Cassini and, three weeks later, landed on Saturn's largest moon, the haze and cloud-enshrouded Titan.

The substantial moon – measuring some 5,150km across – had caught the eye of researchers in the early 1980s, when the Voyager probes passed by the Saturnian system. Their images showed Titan enveloped in a thick atmosphere, but what exactly hid beneath remained a mystery. ESAs Huygens lander delved deeper when, on 14 January 2005, it descended through the atmospheric veil to the moon's frigid surface.

As it drifted down by parachute, the probe's cameras recorded extraordinary pictures of a landscape looming into view below. Upon touching down on the surface, Huygens snapped a now-famous image of icy pebbles littering the frozen ground.

Huygens's battery power soon ran out, but in orbit Cassini continued the investigation. Over the years it has revealed Titan's remarkable network of hydrocarbon seas and lakes, spotted clouds drifting over the surface and even found evidence of what may be waves on some of the seas.

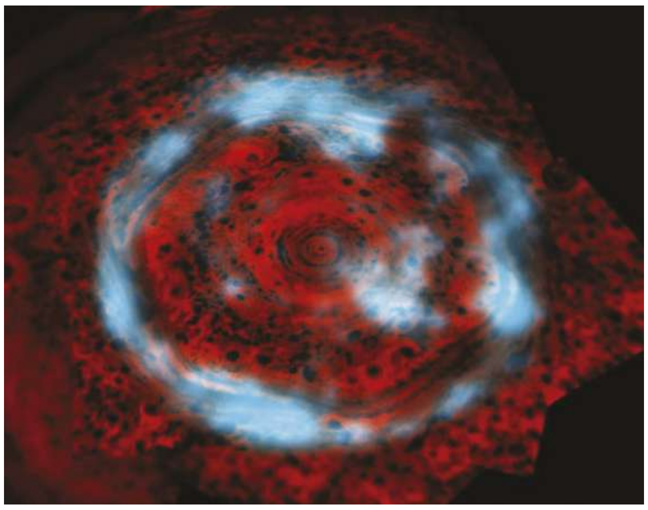
rings. "I have a particular interest in the F ring with all its twists and turns and multiple strands," he says. "It is clearly a very dynamical system and we believe that there is a population of sub-kilometre-sized moons that continuously collide with material in the core of the F ring, creating some of its more spectacular features. Ideally we would like to get high-resolution images of these objects and catch them in the act of colliding."

Amid the ice

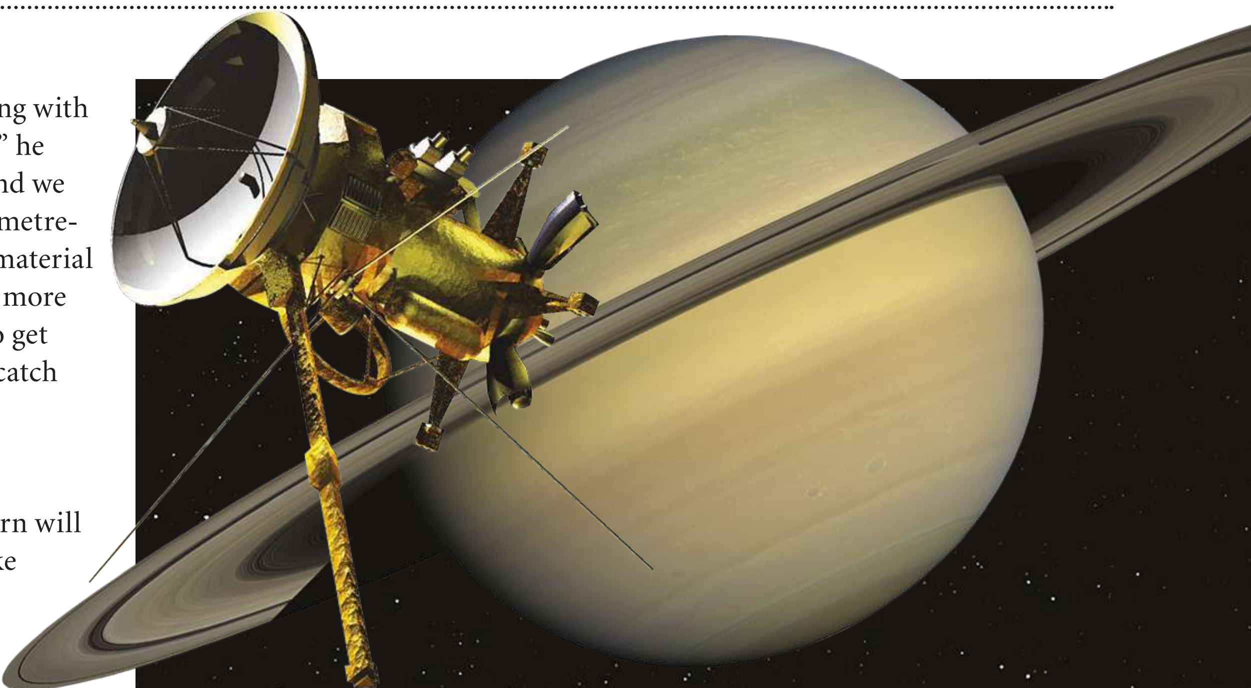
While Cassini's low-diving sweeps over Saturn will allow it to capture beautiful images and make unprecedented scientific observations, the team will also have to make sure that it doesn't get too well acquainted with the countless icy particles that make up the planet's iconic rings. "For the first two [final] orbits we will point Cassini's high gain antenna into the direction of the incoming ring particles using it like a giant shield to protect the rest of the spacecraft," says Spilker. "We don't think that there are many big ring particles in this region but we don't know for sure so we are being careful on the first two orbits. No spacecraft has ever flown in this region between the rings and planet before. That first pass through the gap will be a particularly exciting one!"

As well as carrying the spacecraft close to the planet's rings, the final orbits will also give Cassini's instruments a good view of the polar regions of Saturn, allowing the team to study its aurora. "To be able to understand the aurora best what we're going to need to be able to do is put together data from lots of different instruments," says Prof Michele Dougherty of Imperial College London, who leads the team working on Cassini's magnetometer instrument. "It'll be a combination of remote sensing instruments – so those taking images of the aurora in the ultraviolet, in the infrared and in the visible, the data from the magnetometer and also from the energetic particle instrument as well."

For Dougherty, seeing how this sort of collaboration between Cassini's many scientists has blossomed over the years will be one of her fondest memories of the mission. "There are lots ▸



▲ **The aurora around Saturn's north polar region, captured by Cassini at two wavelengths of infrared light**



REFLECTIONS ON CASSINI

The mission's leading scientists look back on a journey that was decades in the making

DR CAROLYN PORCO Team leader, Cassini's Imaging Science Subsystem

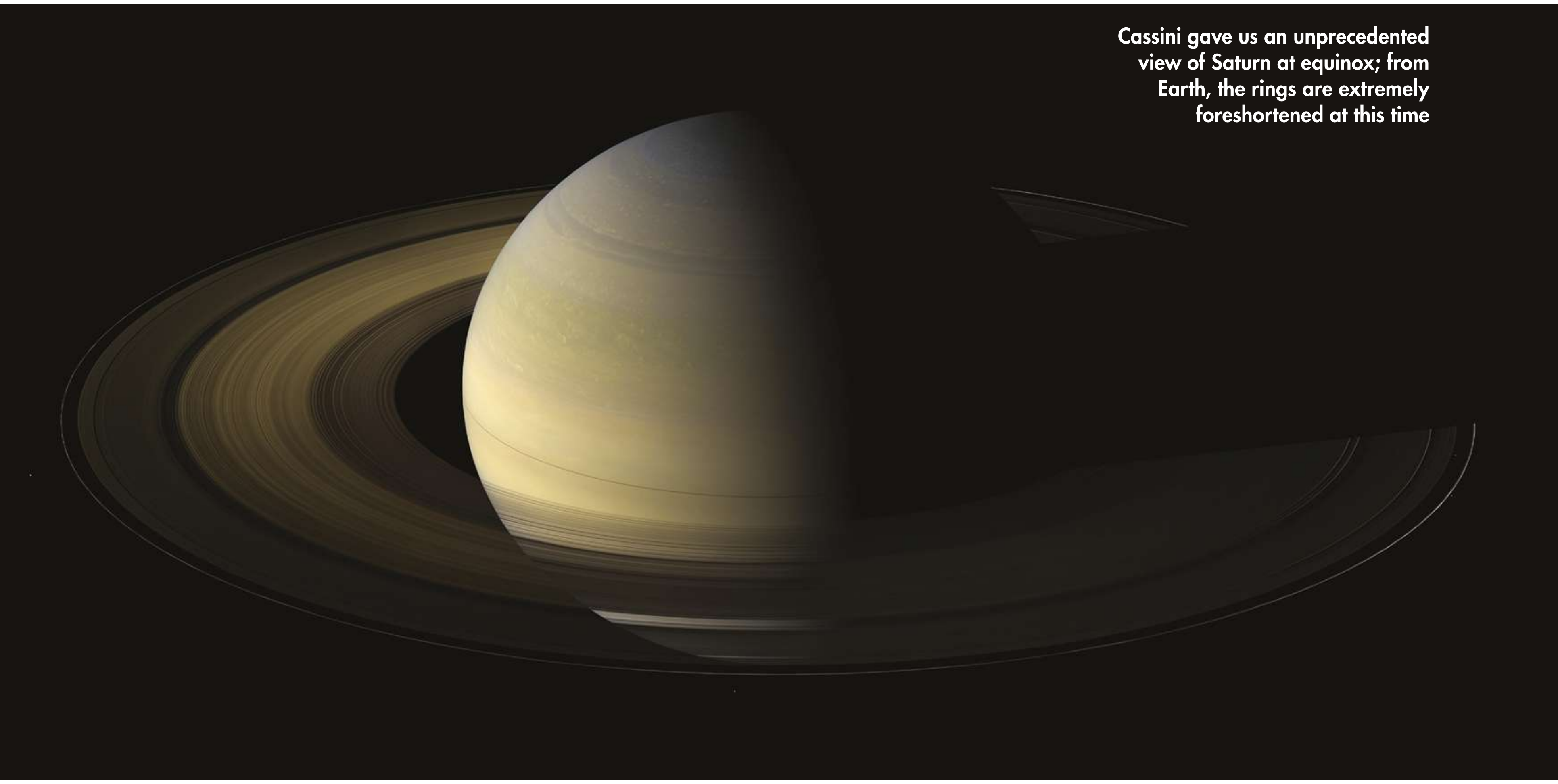
"Cassini hasn't so much been a mission as it's been a way of life. Imagine 27 years on one exploratory expedition through the unknown. The challenges changed over the course of that time, and the job changed along the way, too. I am not the same person I was when I started on this road. There were terribly frustrating times, periods of soul-crushing amounts of work, and moments of ecstasy and exaltation, and all that has made me what I am: a seasoned explorer, who has spent a large part of her life a long, long ways from here, doing something that only few get to do."

DR EARL MAIZE Program manager, Cassini mission

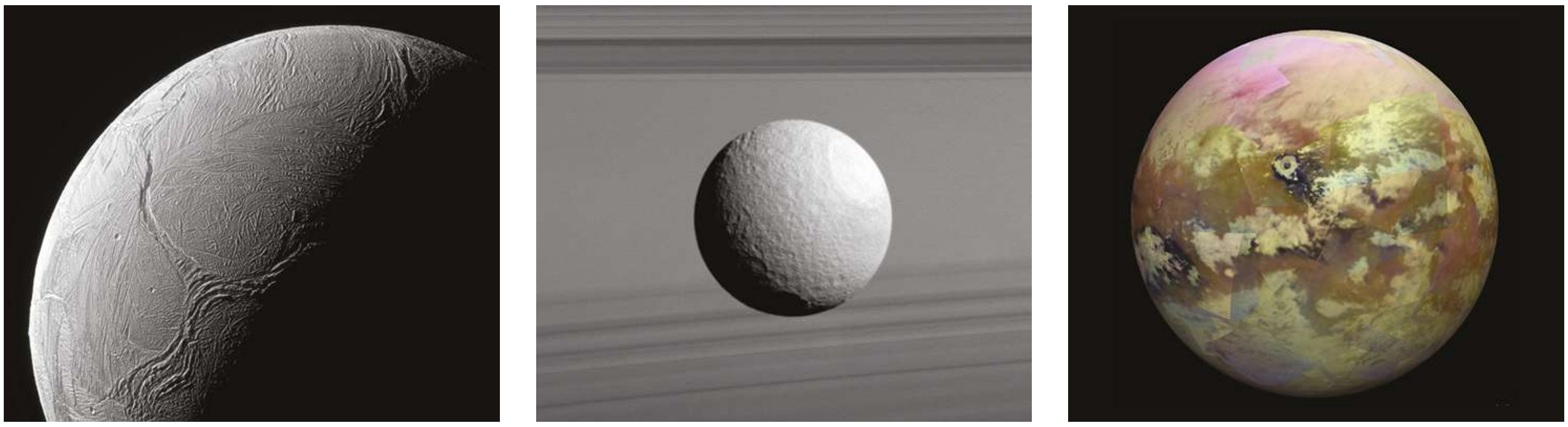
"Probably the most dominant feeling is that it has been one great ride. The Cassini mission, with a nearly flawless spacecraft and instruments, spending 13 years in one of the most fascinating locations in the Solar System: who could ask for more? The mission has found geysers on Enceladus, lakes and rivers on Titan, and myriad other revelations. We've helped rewrite the book on the outer planets and their moons. There will certainly be some poignant moments at mission's end, but I think we'll all go home feeling a great sense of accomplishment."

PROF JOHN ZARNECKI Principal investigator, Surface Science Package, Huygens

"For me, [the most memorable moment] had to be the actual moment of touchdown when we got a signal from the Surface Science Package's penetrometer instrument mounted on the front of the Huygens probe. This told us we had hit something and that the probe had survived for at least a few seconds to be able to transmit that data. It was a moment of enormous emotion and drama – the 15 years had not been wasted. It still amazes me that our little probe had survived the journey to the Saturnian system and had successfully descended and landed on this incredible world – I still find it hard to believe."



Cassini gave us an unprecedented view of Saturn at equinox; from Earth, the rings are extremely foreshortened at this time



Above L-R: A tectonic 'discontinuity' on Enceladus, caused by stresses in the icy shell; Tethys hangs in front of Saturn's rings; and a close-up view of Titan

NASA/JPL-CALTEHC/SPACE SCIENCE INSTITUE X 8, NASA/JPL-CALTECH/UNIVERSITY OF ARIZONA/LPGNANTES

▸ of instruments on board and all the instruments want to point in different directions at the same time," she says. "To begin with all the teams were very protective of their data and their science and they thought it was the most important. But slowly over time you could see people getting to know each other and trust each other and understand each other's science. And I think that was really great to see how the teams began to work together to try and make sure they got the best outcome of science."

Impactful demise

Although the scientific analysis of Cassini's vast data set will continue long after its demise, the spacecraft's physical finish is firmly fixed in the calendar. If it survives its encounter with Saturn's rings, then on the 15 September 2017 it'll hit Saturn roughly 7º south of the planet's equator, says Maize. "We expect a sudden loss of signal. As the atmospheric drag increases, Cassini will not be able to continue to point her radio antenna to Earth," he says. "Soon after aerodynamic heating will destroy the spacecraft." Remarkably, the team hope that even as it heads towards destruction Cassini will be returning valuable scientific measurements. "We have designed the final moments to be as data rich as possible," says Maize. "The most important instrument during those final moments will be our Ion and Neutral Mass Spectrometer. That will be sampling Saturn's atmosphere up until the very last second."

For some working on the Cassini mission, the spacecraft's end won't be their last experience of the outer Solar System. "One of the things that I will be focussing on after Cassini is I've been selected to build [an] instrument for the mission to Jupiter called JUICE," says Dougherty. "By the time we get into orbit around Jupiter in 2030 I'm going to be much crankier and much older than I am now. In some ways I see the Jupiter mission as a way of paying back, so that some of the youngsters who are now coming up will be able to do science that I've been fortunate enough to be able to do at Saturn."

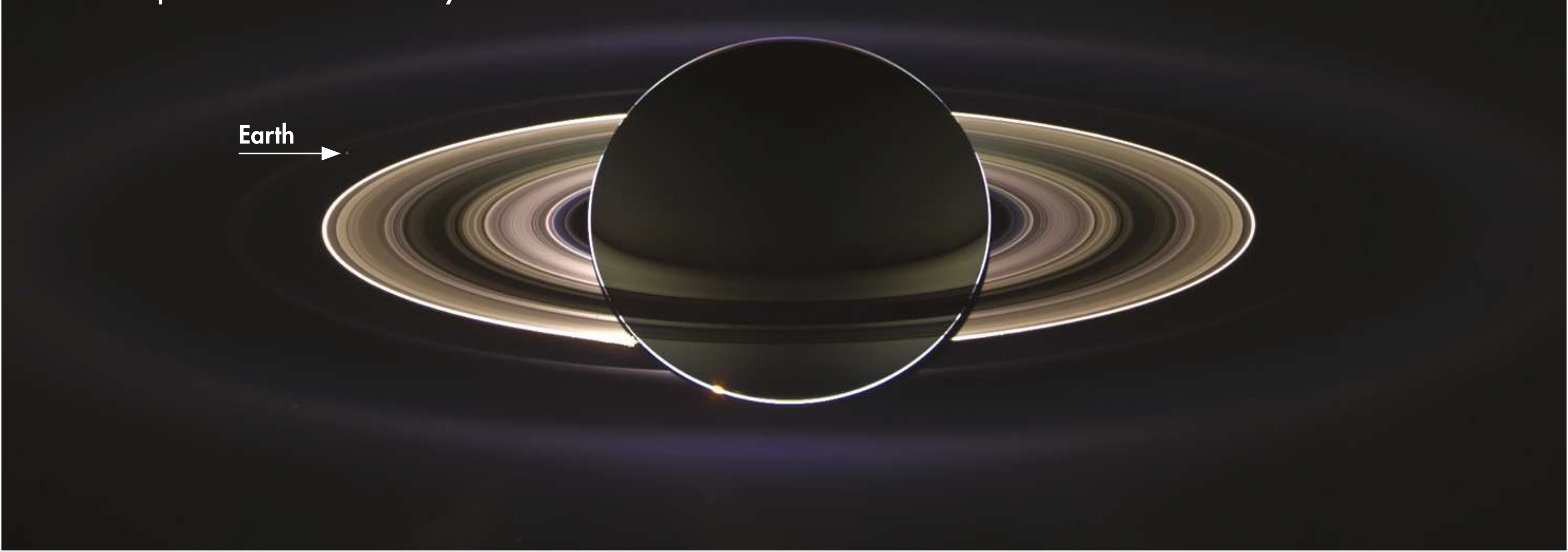
And so as one adventure into the realm of the gas giants ends, a new mission and a new generation of explorers are set to begin another. Ⓢ

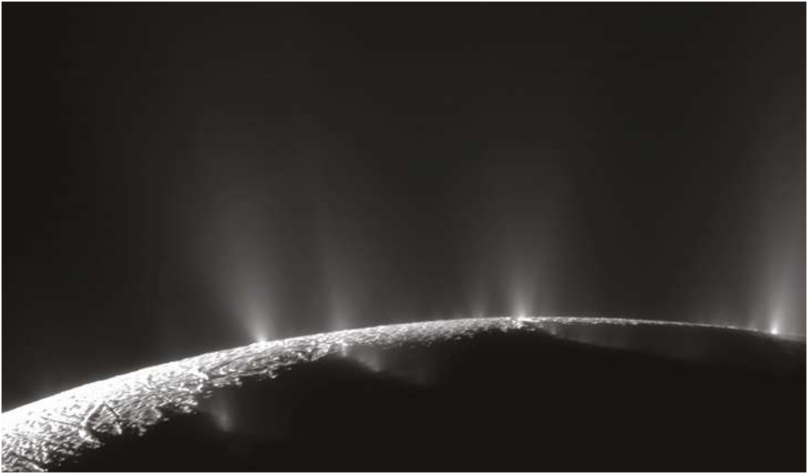
VISIONS OF A RINGED WORLD

Of the thousands of images taken by Cassini, some have really caught our eye

SATURN IN SILHOUETTE

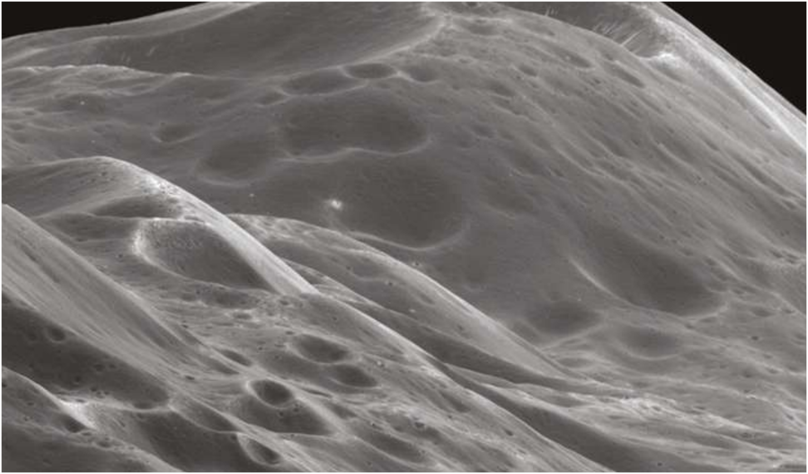
This view of a backlit Saturn and its immense ring system – with Earth just a tiny speck – surely has to rank as one of the finest portraits of the Saturnian system ever.





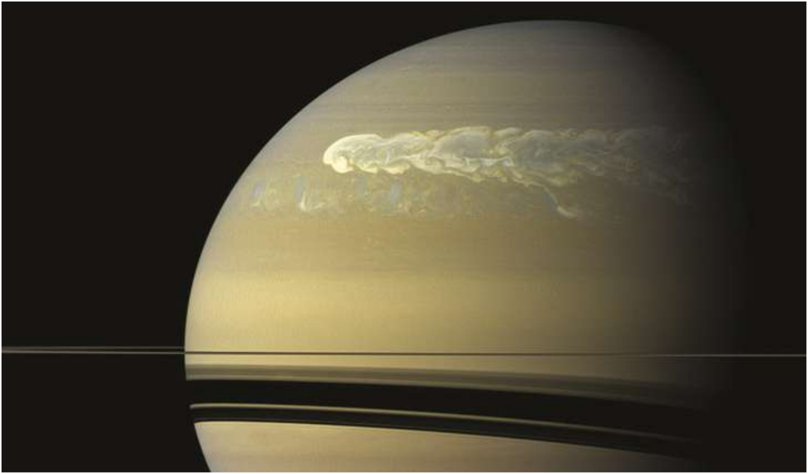
THE JETS OF ENCELADUS CATCH THE SUNLIGHT

In this remarkable image multiple jets of icy material erupt into space from the moon Enceladus. Look closely and you can see them tracing the lines of the surface fissures they originate from.



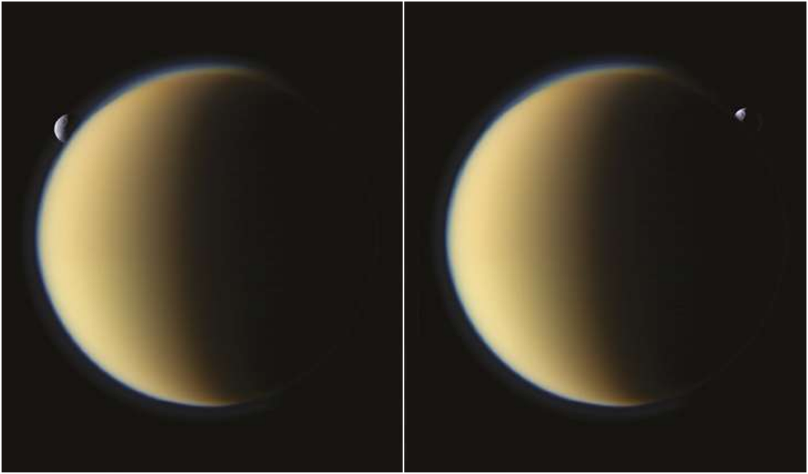
THE ROLLING MOUNTAINS OF IAPETUS

Some of Cassini's most striking images have come as it has flown close to some of Saturn's many moons. Here the spacecraft looks across the 10km high peaks that rise from the equator of Iapetus.



SWIRLING STORM

As it has orbited Saturn, Cassini has been able to monitor changes in the planet's atmosphere. One of the most dramatic events seen by the spacecraft was this vast storm, photographed in 2011.



MOONS IN MOTION

Saturn's natural satellites have featured heavily in imagery returned by the mission. Here the icy Tethys is seen over a million kilometres beyond the hazy cloud tops of Titan.

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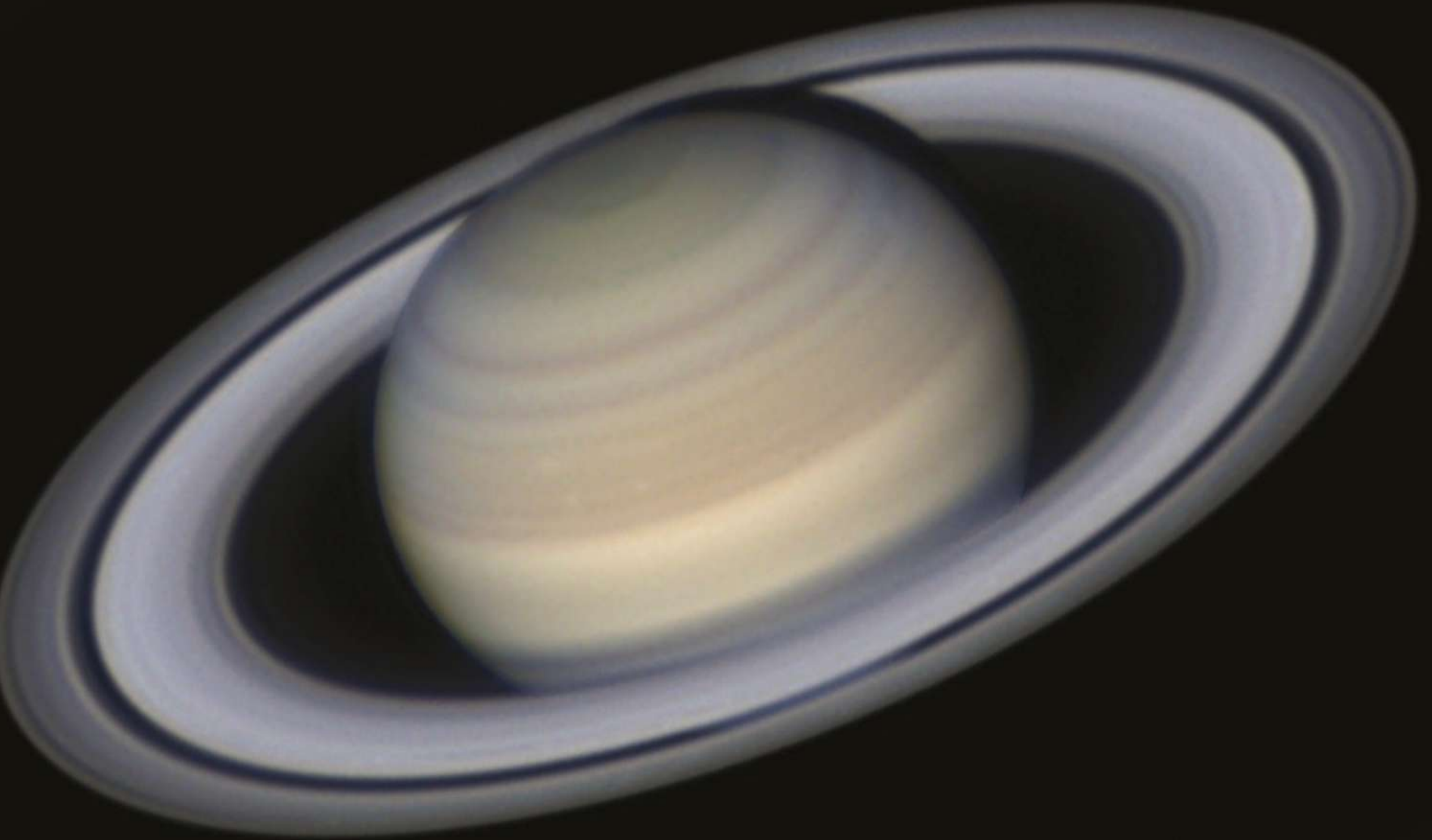

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THE MAGIC OF SATURN

To many, the Ringed Planet is the first 'wow' object they glimpsed through a telescope. **Paul Money** explains how you can see it for the first time

If there is one planet in our Solar System that captures hearts, inspires minds and invokes joy when seen through a telescope it surely has to be the ringed wonder that is Saturn. Even through a modest instrument such as a 2.5-inch spotting scope it is possible to see that the planet is more than a roundish globe. No other planet comes close to capturing the wonder and imagination of young or old when they see Saturn through a telescope for the first time.

Reactions to the view can be interesting. While running a public astronomy event with Saturn as the 'star', a nine-year-old boy took one look through a 10-inch telescope and, for one cheeky moment, exclaimed it had to be a picture stuck to the end of the tube! A tap on the tube as he took another look put him right: the view shimmered and he stepped back amazed, exclaiming, "Wow it really does have rings!"

It is this joy of discovery when someone takes their first look at the beguiling planet which is so inspiring and moving. Saturn, along with the craters on the Moon, is consistently voted as the favourite things to see through a telescope on outreach evenings.

As we head from May into the lighter nights of summer, it's a great time to see Saturn. The planet ▸

ABOUT THE WRITER

Paul Money is our reviews editor and an expert on running astronomy outreach events.

GETTING THE BEST VIEW

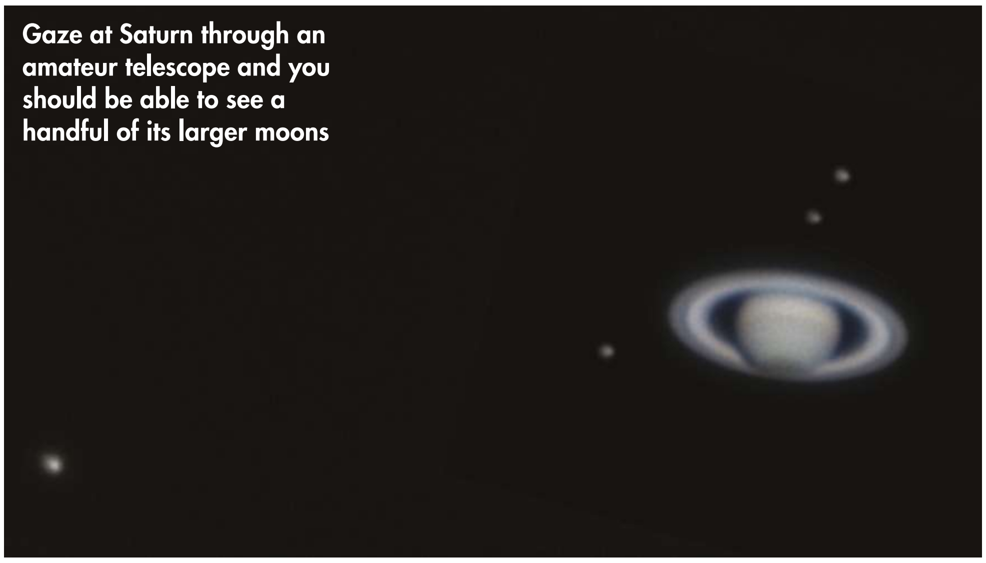
How to make the most of observing the Ringed Planet

A good clear southern horizon is a must for spotting Saturn. Use binoculars first to home in on the planet, then a modest telescope such as a 5-inch reflector or a 3-inch refractor to gain a closer look. When using a telescope, make sure everyone can reach the eyepiece. With reflectors in particular, you can usually rotate the tube to bring the eyepiece to a better position, or have a stool or chair handy. Don't use too high a magnification: it's better to ensure the view remains sharp, even if that means keeping the magnification lower than you'd like.

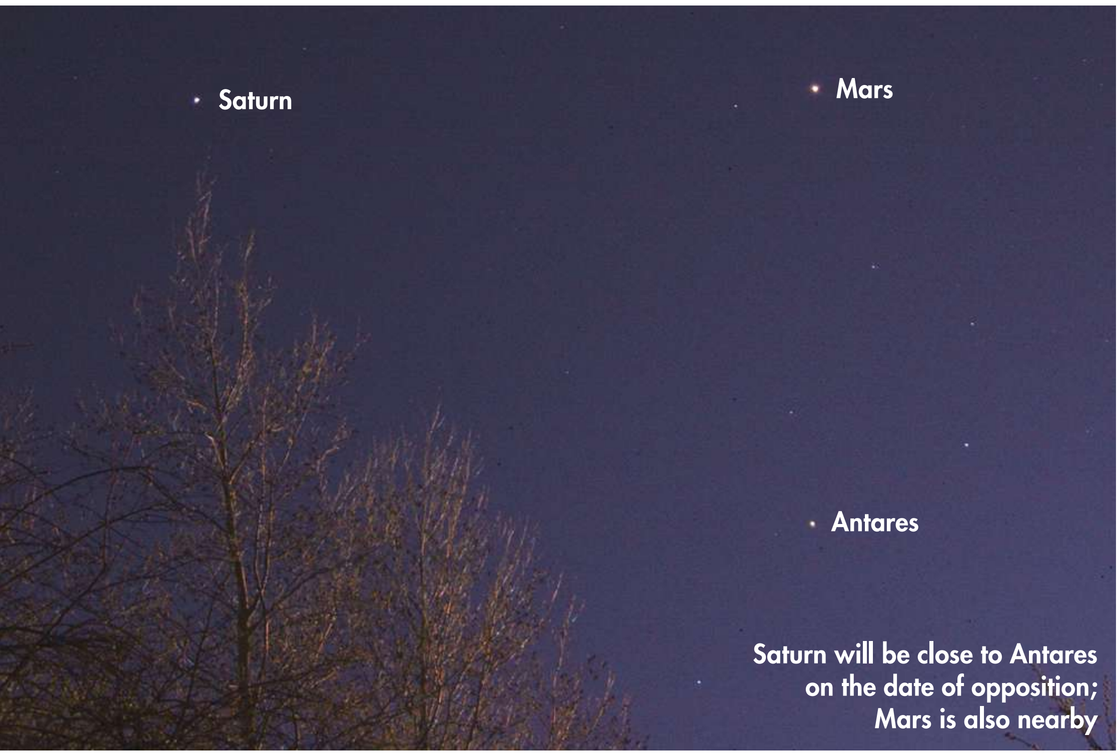
Use a 3-inch reflector or 5-inch refractor for close inspection; binoculars are better for finding Saturn in the first place

▸ comes to opposition – when it is opposite the Sun in the sky, and therefore at its brightest – on 3 June, and in the following months it is visible in the evenings. It will be lying low along the ecliptic – the path of the planets – in the constellation of Ophiuchus, not too far from bright star Antares in Scorpius. As it is so close to the horizon in the evening, you'll need to stay up quite late if you want to catch the planet when it is high in the sky.

On 21 May, Saturn first pops above the horizon around 10pm, before reaching its highest altitude at 2am. At opposition on 3 June it'll already be above the horizon as darkness falls and it gets to its highest point at just past 1am. By mid-June the planet is risen by nightfall and gets to its highest by 11pm, and by mid-July Saturn is at its highest point at twilight around 10pm. Of course, it won't be as bright either side of opposition on 3 June, but it'll still be visible.



Gaze at Saturn through an amateur telescope and you should be able to see a handful of its larger moons

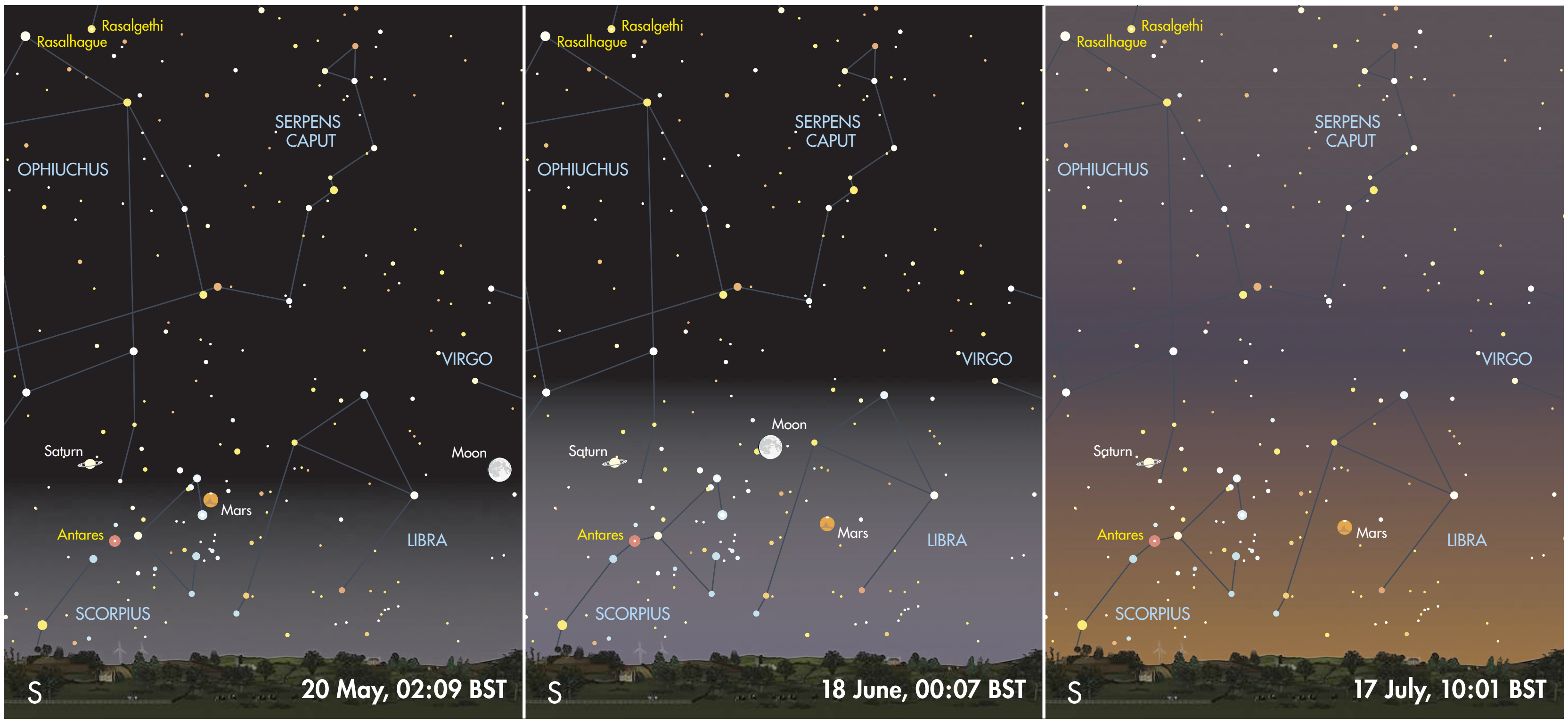


Saturn will be close to Antares on the date of opposition; Mars is also nearby

It is a common mistake to think that you need a large telescope with lots of sophisticated equipment to get the best view of Saturn. The truth is you don't: even a pair of 10x50 binoculars will show that the planet is slightly extended either side of the disc and reveal Saturn's largest moon, Titan, when it is not too close to the planet. Using a 5- to 8-inch reflector or 3- to 5-inch refractor will show more detail. A scope with a long focal ratio of around f/9 to f/12 helps too, as this will make the disc and rings appear larger in the eyepiece.

Stark and golden

Through such instruments the planet can take on a golden hue, in stark contrast to the gleaming white rings, which are currently angled towards Earth. Within the rings you should look for the Cassini



PLANET AND MOON SIZES EXAGGERATED FOR CLARITY

▲ Saturn reaches its highest altitude in the sky progressively earlier as the months go on

Division, the black gap that separates the outer A ring from the brighter B ring. You might even see the inner C ring at times, if the air currents in our atmosphere are steady to provide good seeing. These certainly aren't the only rings Saturn possesses, but they are the easiest to pick out.

The planet itself may also show a dusky northern belt and a polar haze. Through a telescope you'll also be able to bag a few more of Saturn's moons, most likely Rhea, Tethys, Dione and Iapetus. Larger telescopes reveal more subtle detail on the planet, finer detail in the rings and three more moons: Mimas, Enceladus and Hyperion.

If you are showing the view to youngsters, make sure they can reach the eyepiece; perhaps keep a stool or sturdy chair handy for them. Not everyone finds it easy to keep one eye closed as they look through the eyepiece either, so an eye patch can be a useful aid. Some children (and even adults) can struggle looking through an eyepiece. If that's the case, try getting them to look through an empty toilet roll tube; it's surprising how effective this can be in getting them ready for the view through a telescope.

With Saturn best placed during the summer months, now is the time to plan a barbecue, get your friends and neighbours round, let the kids stay up a little later than usual and take a look at the second largest planet in our Solar System. With the added bonus of the spectacular ring system, it is sure to impress. S

JON HICKS, PAUL WHITFIELD X 2, PAUL MONEY, PETE LAWRENCE, CHART BY PETE LAWRENCE, NASA/JPL X 5

TOP 10 SATURN FACTS

As well as being a beauty, the ringed wonder is also a fascinating world

1 Saturn has 62 confirmed moons.

2 The planet is tilted on its axis by 26.7° and therefore has seasons. Each lasts just over seven years because Saturn takes 29.45 years to orbit the Sun.

3 Saturn is a gas giant planet; it is mainly made up of hydrogen and helium. It's thought that a rocky core exists at its centre.

4 On average, Saturn is 9.5 times farther from the Sun than Earth is.

5 Each day on Saturn is only 10.55 hours long. This means that there are 24,470 Saturnian days in one Saturnian year – that's a lot of sunrises and sunsets!

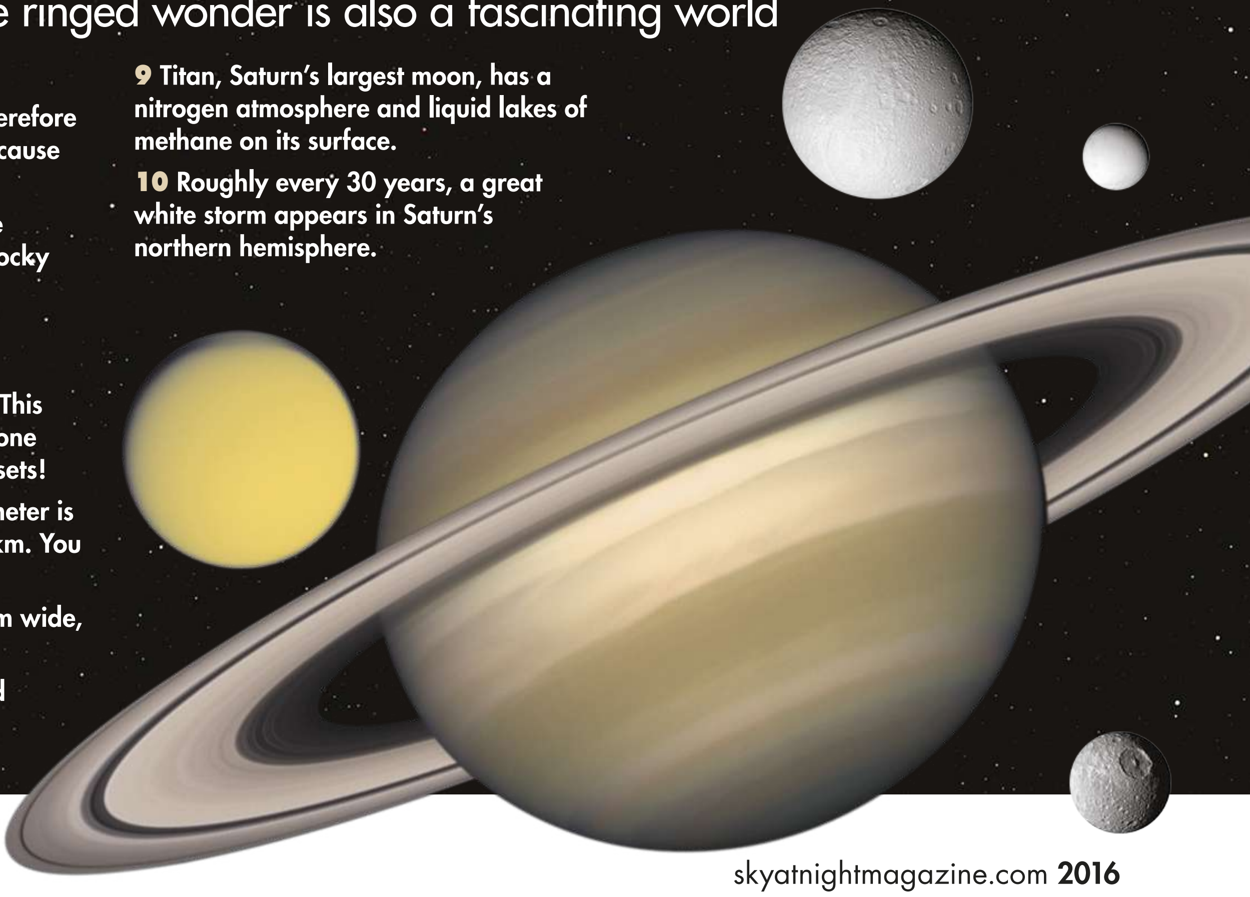
6 Saturn is slightly flattened: its equatorial diameter is 120,536km while its polar diameter is 108,728km. You could fit 9.5 Earths across its disc.

7 The ring system out to the A ring is 273,550km wide, but only 1km thick.

8 Saturn is a windy planet, with gusts measured by Voyager at 1,800km/h.

9 Titan, Saturn's largest moon, has a nitrogen atmosphere and liquid lakes of methane on its surface.

10 Roughly every 30 years, a great white storm appears in Saturn's northern hemisphere.



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Return to Earth

As Tim Peake prepares to leave the International Space Station, **Nick Spall** reviews the UK astronaut's orbital experiences

ESA/NASA X 2

Peake gives a thumbs up shortly after his arrival on the ISS

After an action-packed six months aboard the International Space Station, 400km above Earth, UK astronaut Tim Peake will return to terra firma on 18 June. When it concludes, Peake's *Principia* mission will be ESA's sixth longest, and will have delivered extensive science and technology research that is likely to have benefits we can't yet imagine.

Peake soared skywards along with Russian cosmonaut Yuri Malenchenko and NASA's Tim Kopra on Soyuz flight TMA-19M, which launched from Baikonur Cosmodrome in Kazakhstan on 15 December 2015. All went smoothly and those watching the launch live on BBC One saw Peake grinning at the cameras from behind his Sokol spacesuit visor and giving the thumbs up during the nine-minute trip to low-Earth orbit.

The planned four-orbit rendezvous with the ISS went well, but excitement occurred when the docking system failed and the Soyuz spacecraft backed away rapidly from the ISS, but Malenchenko coolly took over and performed a manual docking. Two and a half hours later they were able to board, and found the three astronauts already on the ISS – NASA's Scott Kelly and Russia's Mikhail Kornienko and Sergei Volkov – waiting to give them a warm welcome.

Settling into space

Settling in to life in microgravity normally takes time as space adaptation syndrome can cause nausea. Videos showed Peake moving around the station cautiously at first, with the puffy face that new arrivals to the ISS generally have, but he acclimatised quickly: after 48 hours he was able to show off smooth zero-g somersaults as he joined press link-ups and went about his daily routine tasks.

The crew celebrated Christmas on the ISS and, on 7 April, Peake marked his 44th birthday. Both passed without alcohol, however: this isn't permitted on the ISS as it would interfere with the urine recycling system, and because the medical consequences of six months in microgravity are serious enough without a hangover. He will have experienced a gradual loss of bone and muscle density, heart muscle weakening, fluid shifts throughout his body and possible changes to his intracranial pressure, potentially leading to a deterioration in eyesight.

Peake exercises for two hours a day to fight these issues, and also so that when he is lifted out of the Soyuz after landing he can recover quickly. This is especially important if the returning crew have to speedily exit the capsule on landing or

ESA/NASA X 8

From L-R: Peake arrives on the ISS; juggles with fresh fruit; and poses with the rocket seeds destined for British schools

Peake will return to Earth in a Russian Soyuz capsule

TIM'S TRIP HOME

What happens when as astronaut leaves the ISS

When 18 June comes and it's time to return to Earth, Peake, Kopra and Malenchenko will pass through the airlock into the waiting Soyuz spacecraft that will take them back home. Once in the tiny re-entry capsule they will strap into their custom-lined seats and detach from the ISS.

Travelling at 27,500km/h they will need to fire the retro-rockets to slow the spacecraft down before the fiery re-entry into the Earth's atmosphere 60 minutes later. At 100km above ground level, the service and orbital modules separate. As the Soyuz capsule continues its descent its outer layer heats up to about 1,650°C, its ablative surface burning off to absorb this energy.

Inside the capsule, the crew will experience a 4-5 g deceleration load on their bodies on an angled descent path or, if the re-entry is ballistic (almost straight down), the strain could be as high as 12 g. At 10km altitude, the drogue and main parachutes open and, with a final cushioning blast from the small landing retro rockets, the crew touch down onto the Kazakh Steppe.

Peake will then be flown to ESA's Astronaut Centre in Cologne for extensive medical tests, including blood and MRI scans, plus a full team debriefing. It is likely that he will feel weak after six months in space and will be highly attuned to bright colours and smells. Even wearing clothes in normal gravity may feel odd at first: on his return NASA's Scott Kelly reported itchy skin because of this. There will be several days' adaptation, before Peake embarks on a European tour to pass on his amazing experiences to the public.

touch down off target and need to survive in the wild for a time.

An early mission highlight for Peake occurred on 15 January, with a spacewalk to replace a failed voltage regulator and fit electrical cabling to allow for future commercial spacecraft dockings. At first the spacewalk went smoothly and the faulty unit was properly replaced.

Additional tasks were being carried out when fellow spacewalker Tim Kopra suddenly announced that he had a small amount of water leaking into his spacesuit helmet. This had occurred previously: in 2014 ESA astronaut Luca Parmitano had survived a very difficult return to the ISS airlock with virtually no visibility through his helmet due to water floating in front of his face. It was thought then to be due to a failed cooling unit seal in the spacesuit.

Taking no chances, the two Tims called time on their spacewalk and quickly returned to the airlock. The four hour, 43 minute-long EVA was a first for the UK and, of course, for Peake himself. Speaking about it later he said it "...would be etched on my memory forever – quite an incredible feeling".

Science trials

Since then Peake has been busy performing research and outreach work, taking part in over 30 experiments, 12 of which are UK/ESA led. Carrying out science research on the flying laboratory that is the ISS is a key task for the six-man crew; in fact, there are more than 250 experiments that are ongoing.

Materials science work has been an extensive part of Peake's mission, as have medical tests to investigate important Earth-related topics such as how the human body ages. Another task was the METERON robotic control link-up with a model Martian rover called 'Bridget' based at Stevenage in the UK. This was a test to see whether Peake could control the rover remotely, and validated technology intended for future lunar and Martian missions that will allow astronauts in orbit to operate surface robots remotely.

The *Principia* mission has also involved an extensive schools outreach programme, part of which involved taking 2kg of salad rocket seeds up to the ISS. These were returned to Earth by NASA's Scott Kelly when he concluded his year-long stay on the ISS in March, and will eventually be distributed to more than 8,000 schools in the UK, where they will be grown alongside other rocket seeds that have remained on Earth.

Aside from this horticultural endeavour, Tim is taking on projects such as Into Film: Into Space to encourage film-making in schools, Mission X to train and eat like an astronaut, the Space to Earth Challenge to inspire students to run, ▸

From L-R: Peake commands an Earthbound rover; has his blood drawn for later analysis; and performs one of many experiments

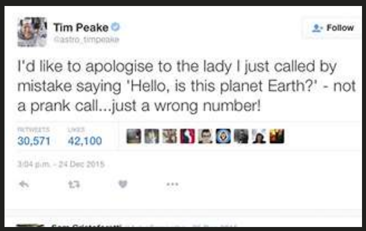
TIM'S TOP MEDIA MOMENTS

Even with a crammed science schedule, Peake found time for a bit of fun

▲ Peake has shared his mission through videos (https://principia.org.uk), blogs (http://blogs.esa.int/tim-peake), tweets (https://twitter.com/astro_timpeake) and photos (www.flickr.com/photos/timpeake). Memorable posts include the ultimate EVA selfie, delivering a 'God save the Queen' message to Elizabeth II, and speaking via video uplink to Parliament's Science and Technology Committee in March.

◀ Fellow astronaut Scott Kelly donned a gorilla suit to celebrate his birthday, resulting in a YouTube hit that sees Peake being chased through the modules of the ISS by a wild-looking great ape.

▲ On 24 April, Tim joined the 37,000 participants running the London Marathon from orbit – though he did it in zero-g on a treadmill in what he described as "the highest and fastest gym in the Universe".



Tim Peake
@astro_timpeake
Follow

I'd like to apologise to the lady I just called by mistake saying 'Hello, is this planet Earth?' - not a prank call...just a wrong number!

RETWEETS 30,571 LIKES 42,100

3:04 p.m. - 24 Dec 2015

▲ Shortly after he joined the ISS, Tim tried to call home, got the wrong number and said to a confused woman: "Hello, is this planet Earth?" He later took to Twitter to send a lighthearted apology.

ESA/NASA X 2, TIM PEAKE/TWITTER, WWW.YOUTUBE.COM/TWITTER/SCOTT KELLY, SPORTLOCKER

▸ cycle and swim, and Story Time From Space to read kids bedtime stories from orbit. He has also worked with Heston Blumenthal on food experiments. The famous chef prepared him beef stew, which Tim said "melted in the mouth", and also bacon sandwiches. He also had tea prepared in a pouch for him by NASA; though it was made with cream, not milk.

The Dragon arrives

On 11 April, SpaceX launched a Dragon resupply freighter and Peake successfully used the robotic arm on the ISS to grapple with the five-tonne craft and dock it to a free port on the ISS. He coolly announced: "We show load is safe and it looks like we've caught a Dragon!" The freighter carried three tonnes of supplies, including a group of mice for medical tests, some Chinese cabbage seeds and the BEAM expandable habitation pod, a prototype inflatable structure developed by Bigelow Aerospace, which will undergo tests over the next two years.

But Peake will be back long before those tests are done. The return flight will give him a chance to reflect on his long six-month stay in low-Earth orbit. Many astronauts report how they experience deeply felt emotions from seeing the stunning view of a borderless planet passing many miles below. Some note how beautiful and fragile the Earth appears from space. No doubt he will also be thinking to the future, which is looking relatively rosy. The ISS is set to be maintained in orbit for another 10 years at least, after all. Ⓢ

ABOUT THE WRITER

Nick Spall is a freelance space writer. He's interviewed astronauts, experienced zero-g parabolic flights and high-g in centrifuges.

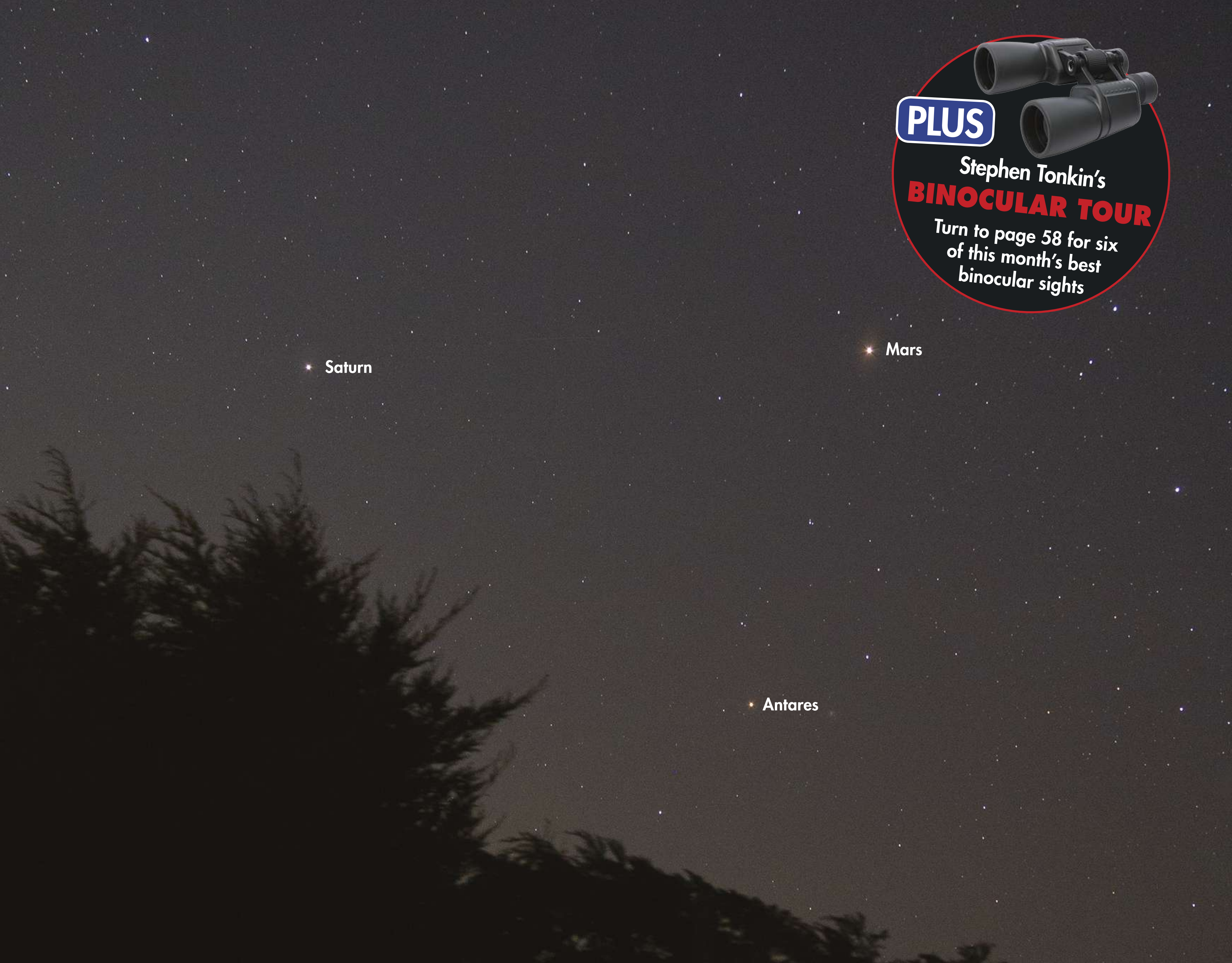
BBC NEWS

Keep up to date with Tim Peake's return with BBC News and its science editor David Shukman: @davidshukmanbbc

YOUR BONUS CONTENT

Watch a selection of ESA videos showcasing Tim's 'best bits' on the ISS

When the experiments are done for the day, astronauts can retreat to the Cupola for out of this world views of Earth



PETE LAWRENCE

PLUS
Stephen Tonkin's
BINOCULAR TOUR
Turn to page 58 for six of this month's best binocular sights

The Sky Guide June

Both Mars and Saturn grace the summer sky this year, visible together low in the south not too far from Mars's rival, the red supergiant Antares. Saturn reaches opposition on 3 June, and despite its low altitude, this is the best time to view it with a telescope.

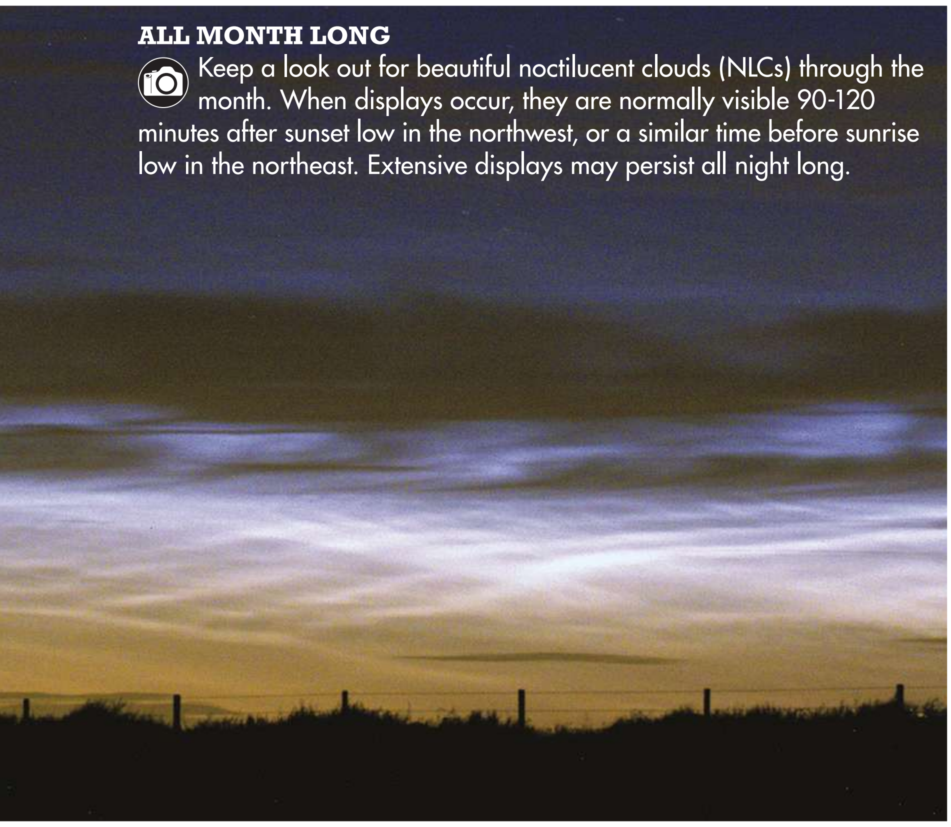
Written by Pete Lawrence

Pete Lawrence is an expert astronomer and astrophotographer with a particular interest in digital imaging. As well as writing *The Sky Guide*, he appears on *The Sky at Night* each month on BBC Four.

Highlights

Your guide to the night sky this month

This icon indicates a good photo opportunity



ALL MONTH LONG

Keep a look out for beautiful noctilucent clouds (NLCs) through the month. When displays occur, they are normally visible 90-120 minutes after sunset low in the northwest, or a similar time before sunrise low in the northeast. Extensive displays may persist all night long.

1 WEDNESDAY ▶

With the Moon largely out of the way, this is the best part of the month to track down some of the summer showpiece objects such as the Ring Nebula (M57), Dumbbell Nebula (M27) and the beautifully coloured binary star Albireo (Beta (β) Cygni).

3 ◀ FRIDAY

Saturn is at opposition today. It is around opposition that the rings brighten due to the Seeliger Effect. The planet is currently in the southern region of Ophiuchus. See page 52 for observing advice and page 60 for imaging tips.

6 MONDAY

Venus reaches superior conjunction today, when it will line up with the Sun on the far side of its orbit. Although you can't observe this directly, it is still possible to watch Venus re-emerge from behind the Sun via the SOHO mission website.

10 FRIDAY

Today is the start of the weak annual June Lyrid meteor shower. The shower peaks on the night of 15/16 June but this year visibility is unfavourable thanks to the Moon.

Titan reaches greatest eastern elongation from Saturn today.

11 SATURDAY ▶

The waxing crescent Moon (44% lit) is 2° south of Jupiter – but in broad daylight. Locate them by finding the Moon at 18:50 BST (17:50 UT); it will be due south, roughly halfway up the sky. Use binoculars or a scope to glimpse ghostly Jupiter, four apparent Moon diameters above and slightly left.

PETE LAWRENCE X 7

19 ◀ SUNDAY

As Saturn is only just past opposition, when the Moon is close to the planet this month, it too will be close to its own opposition position and will appear almost full. The Moon will be 97% lit and lie 2.3° from the Ringed Planet at 02:00 BST (01:00 UT)

20 MONDAY

The Sun reaches the June solstice at 23:34 BST (22:34 UT). This represents the point in its apparent motion around the sky where the rate of change of declination with time, for an instant, is zero.

27 MONDAY

It may be rather dim and distant but, as we now know from the New Horizons mission images, Pluto is a rather beautiful world. Tonight, its mag. +14 dot lies close to the mag. +2.9 Pi (π) Sagittarii. See page 50.

29 WEDNESDAY ▶

The Teapot asterism in Sagittarius is due south and visible just above the horizon around 01:00 BST (00:00 UT). The fact that the sky isn't getting properly dark at the moment may actually help identify the pattern as the fainter stars in the area will be harder to see.

2 THURSDAY ▶
This is the best part of the month to try our Deep-Sky Tour on page 56; this month we're looking at low objects close to the red supergiant star Antares in Scorpius.

Titan, Saturn's largest moon, reaches greatest western elongation from the planet today.

4 SATURDAY
📷 Two planets and a star are forming a distinctive pattern low in the south. Mag. –1.9 Mars, mag. +0.4 Saturn and mag. +1.0 Antares (Alpha (α) Scorpii) form an attractive right-angled triangle; Antares is at the 90° angle.

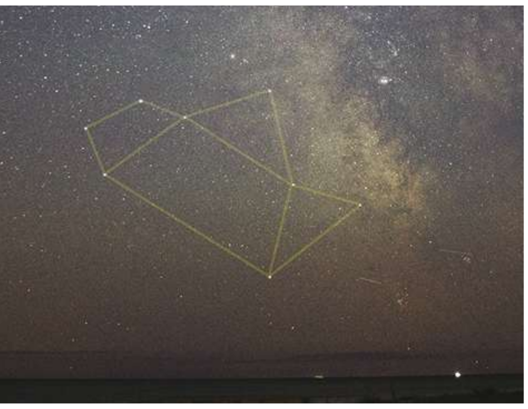
5 SUNDAY
Mercury reaches greatest western elongation in the morning sky, appearing separated from the Sun by 24°. Its sky position isn't the best unfortunately; it'll be a real struggle to catch sight of the planet low down in the east-northeast just before sunrise.

15 WEDNESDAY
📷 The waxing gibbous Moon (81% lit) occults mag. +4.2 Kappa (κ) Virginis this evening. It vanishes behind the dark lunar limb at 23:12 BST (22:12 UT) and emerges from the bright one at 00:31 BST on the 16th (23:31 UT on the 15th). Times are for the centre of the UK.

18 SATURDAY
Titan reaches greatest western elongation from Saturn today. It is possible to glimpse Titan using binoculars and a steady hand.

25 SATURDAY
Saturn's moon Titan reaches its second eastern elongation from the Ringed Planet for the month.

26 SUNDAY
Neptune reappears from a lunar occultation at 00:39 BST this morning (23:39 UT on the 25th). This will be a challenging spot because of the planet's low altitude and is best suited for those living in the east of the UK. See page 51.



30 THURSDAY
It isn't easy observing close to the June solstice because the sky never gets truly dark. If you have a relatively flat southern horizon and a pair of binoculars try and spot the pair of clusters close to the tail of Scorpius, M6 and M7. M7 is the most southerly of all the Messier objects.

What the team will be observing in June

Pete Lawrence "I'll be looking out for noctilucent clouds. Last year's displays were weak, but that doesn't mean this year's will be. With the nights so short, you can do both the evening and morning watch in one session."

Steve Marsh "I'm looking forward to imaging Saturn during its opposition this month. With my 8-inch scope it is always a very challenging target given its low altitude but it's too good an opportunity to miss."

Paul Money "Saturn reaches opposition on 3 June and although it is quite low for us I will be trying to image and view it and its moons as much as I can."

Need to know

The terms and symbols used in *The Sky Guide*

UNIVERSAL TIME (UT) AND BRITISH SUMMER TIME (BST)

Universal Time (UT) is the standard time used by astronomers around the world. British Summer Time (BST) is one hour ahead of UT.

RA (RIGHT ASCENSION) AND DEC. (DECLINATION)

These coordinates are the night sky's equivalent of longitude and latitude, describing where an object lies on the celestial 'globe'.

HOW TO TELL WHAT EQUIPMENT YOU'LL NEED

👁 **NAKED EYE**
Allow 20 minutes for your eyes to become dark-adapted

🔭 **BINOCULARS**
10x50 recommended

📷 **PHOTO OPPORTUNITY**
Use a CCD, planetary camera or standard DSLR

🔭 **SMALL/MEDIUM SCOPE**
Reflector/SCT under 6 inches, refractor under 4 inches

🔭 **LARGE SCOPE**
Reflector/SCT over 6 inches, refractor over 4 inches

GETTING STARTED IN ASTRONOMY

TAP HERE
For our 10-step guide to getting started

TAP HERE
For advice on choosing your first scope

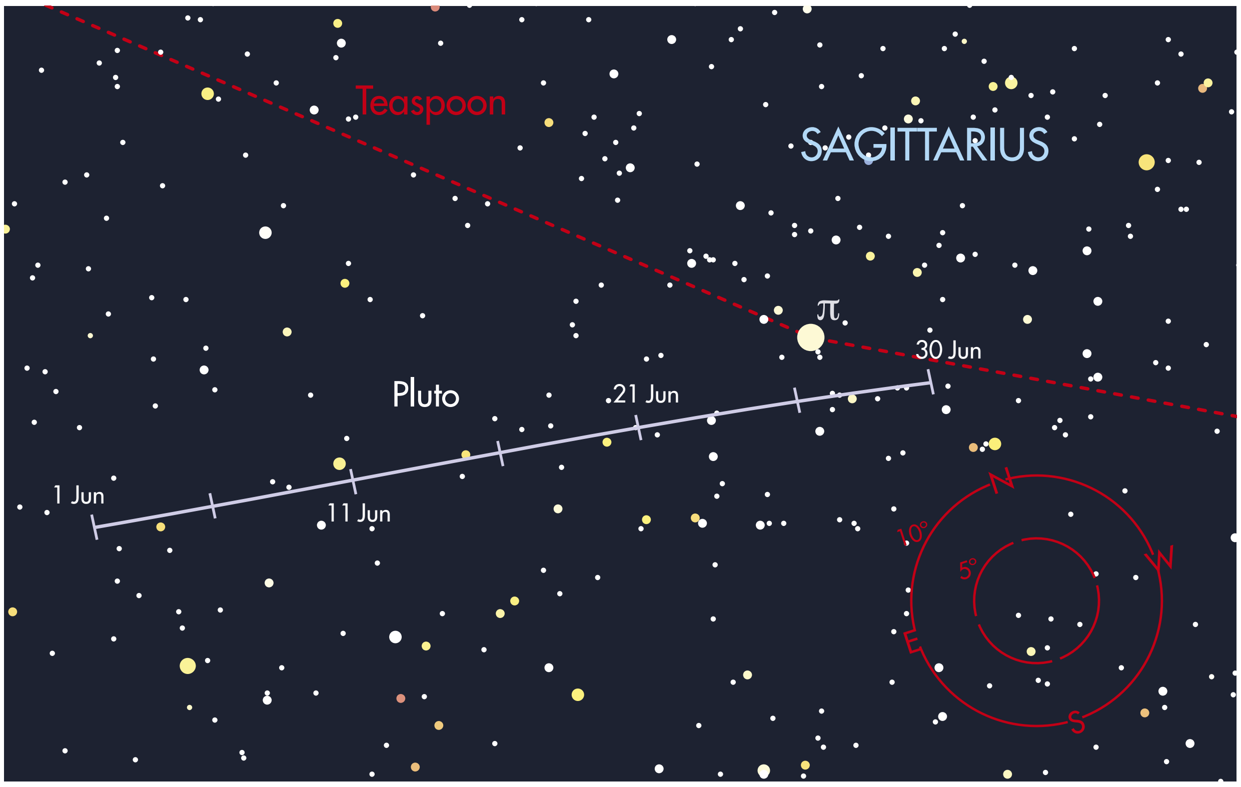
DON'T MISS... 3 top sights

Chasing Pluto

WHEN: All month, though the Moon will interfere from 13-27 June

NEED TO KNOW

An object's brightness is given by its magnitude. The lower the number, the brighter the object: with the naked eye you can see down to mag. +6.0.



▲ Pluto is closing in on Pi Sagittarii, which becomes a great aid to finding the faint planet later in the month

DWARF PLANET PLUTO is undergoing something of a renaissance thanks to the revelations of last year's close flyby of the New Horizons spacecraft. Our mind's eye image of this distant world used to be of a cold, dark, inactive place. Admittedly it's still cold, but we now know that it's certainly not inactive, showing evidence of a surface has been sculpted by dynamic geological processes.

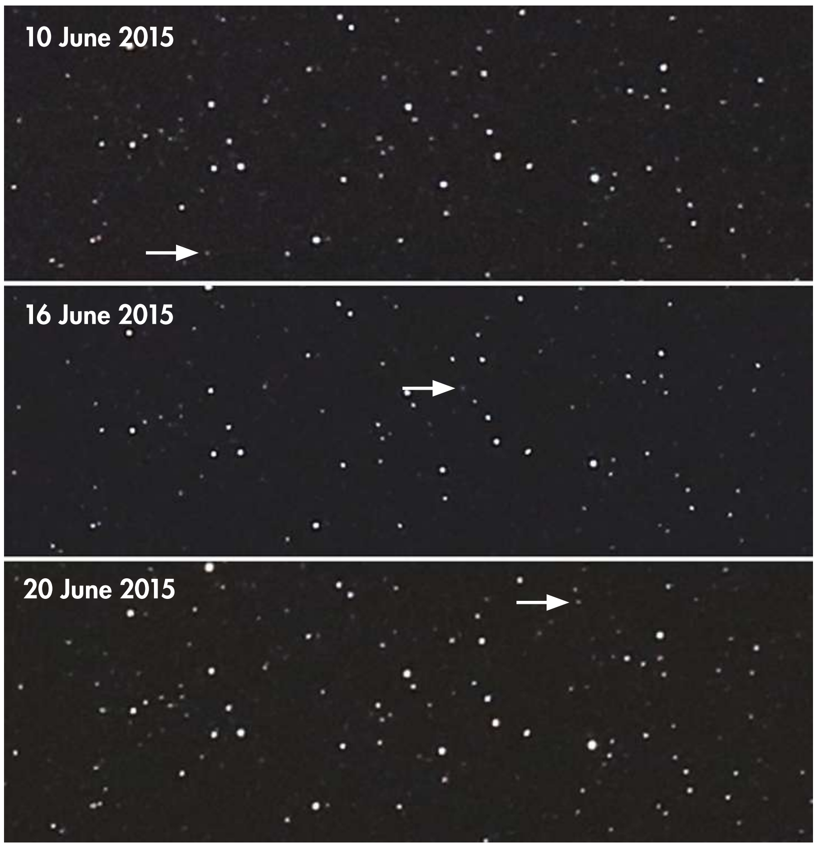
For those of us who love to look up at the heavens, Pluto is a challenging object. Hovering around mag. +14.0, in theory it requires a large aperture of 12 inches or more to even stand a chance of catching it. We say 'in theory' because there are reports from respected observers who claim they have seen it in much smaller instruments. From the UK, at least, this would be hard to do because Pluto has a relatively low altitude.

However, while the eye may struggle to catch Pluto, a camera can fare a lot better. A DSLR with a lens of 200mm or longer focal length stands a chance of capturing Pluto as a faint dot. Although this will be very hard to identify in a single image, the planet's relative motion against the background stars will give it away in a sequence of shots taken over several nights.

If you plan to attempt this a tracking setup is recommended but the exposure doesn't need to be excessively long – 30-60 seconds at a relatively high ISO should do it. The trick is to magnify the photograph (by quite a lot) in the region where Pluto should be in order to find it. Later in the month, Pluto will be approaching the star Pi (π) Sagittarii, which at mag. +2.9 is a veritable beacon compared to Pluto. This will act as a great navigational aid and target to aim at, and will improve your chances of capturing a shot of the distant dwarf planet enormously.

Pi Sagittarii is located to the northeast of the famous asterism in Sagittarius known as the Teapot. The star forms part of another tea-related asterism known as the Teaspoon, marking the point where the handle of the spoon joins its bowl.

Pluto has been moving inside the bowl for a while now. This location is right on the edge of the rich starfields of the Milky Way and presents you with a view of many faint stars, all of which help to camouflage Pluto. Despite this, flipping between aligned images taken over the course of several nights should easily reveal something that's moving in a regular manner. It reaches opposition on 7 July.



▲ A sequence of shots over several nights can reveal Pluto's motion

PETE LAWRENCE X4

Neptune reappears

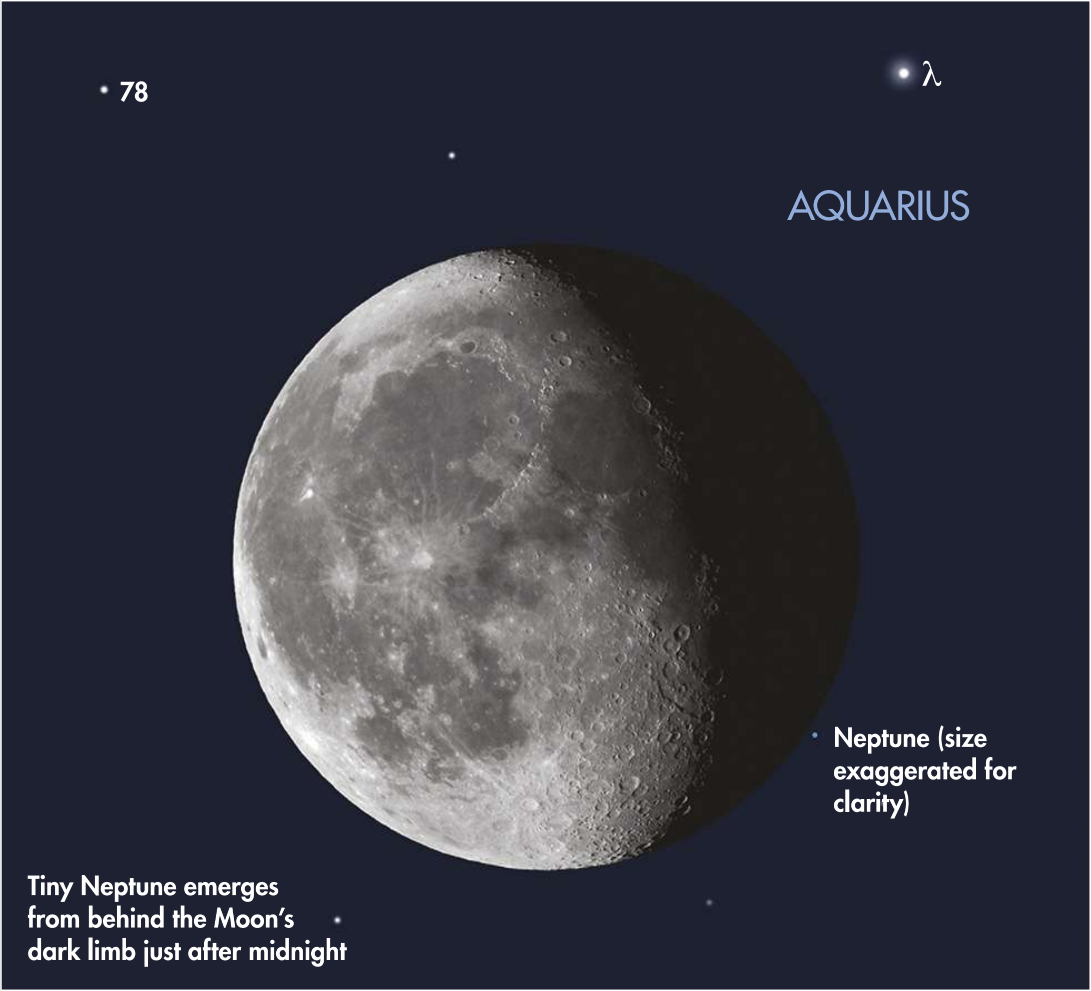
WHEN: 26 June from 00:20

THE PLANET NEPTUNE will be hidden by a 69%-lit waning gibbous Moon on the night of 25 June, but this occurs when both objects are below the horizon. The reappearance occurs at 00:39 BST on the 26th (23:39 UT on the 25th), when the Moon will be very low, just 1.5° over the eastern horizon. These values are correct for the centre of the UK but, due to the extremely low altitude, improve quite noticeably for those who live more to the east. For example, from Norwich, reappearance occurs when the Moon is 4° up.

If the atmosphere is murky, this will probably hide the reappearance, but if it's transparent the event should be visible despite the low altitude. Neptune will be at mag. +7.9 and so can be seen with binoculars. The planet will emerge from behind the Moon's southeast dark limb.

If nothing else, this is a good excuse to catch the rising Moon, which can look quite amazing in its own right as its light is bent and distorted by the thick band of atmosphere close to the horizon. This low down, the Moon can often appear red in colour as it rises. Unfortunately, this effect can also make objects appear dimmer than they actually are, which isn't in Neptune's favour.

Don't forget that the Moon and Neptune will remain fairly close together for a short while after reappearance. At 01:10 BST (00:10 UT) for example, they will be separated by 0.5° as measured from the centre of the Moon's disc and have a more acceptable altitude of 8°. Neptune will appear 0.25° from the Moon's dark limb at this time. With an apparent diameter of just 2.3 arcseconds, Neptune's tiny blue disc appears 1/826th the apparent size of the Moon.



Tiny Neptune emerges from behind the Moon's dark limb just after midnight

Noctilucent clouds

WHEN: All month

THESE 'NIGHT SHINING' clouds form at a height around seven times higher than the highest normal (tropospheric) clouds. At this height, they are able to reflect the Sun's light even when our star is below the horizon. The best times to look out for them are 90-120 minutes after sunset, when they may appear low in the northwest, or a similar time before sunrise when they may be seen low in the northeast.

Bright displays can shift position from the northwest, through north and towards the northeast throughout the course of the night. This occurs because the display tracks the position of the Sun. If present, they typically have an electric blue colour, often with a network like structure. A bright noctilucent cloud display also makes for a great photographic target.

Thought to form around the tiny fragments left over after meteors vaporise in the mesosphere, the ice crystals that comprise the clouds can easily catch you out. It's not unknown for noctilucent cloud hunters to keep vigil for several days, only for a display to appear on the night they have off. Similarly, the appearance of a bright display one night doesn't guarantee it'll still be there the following night.

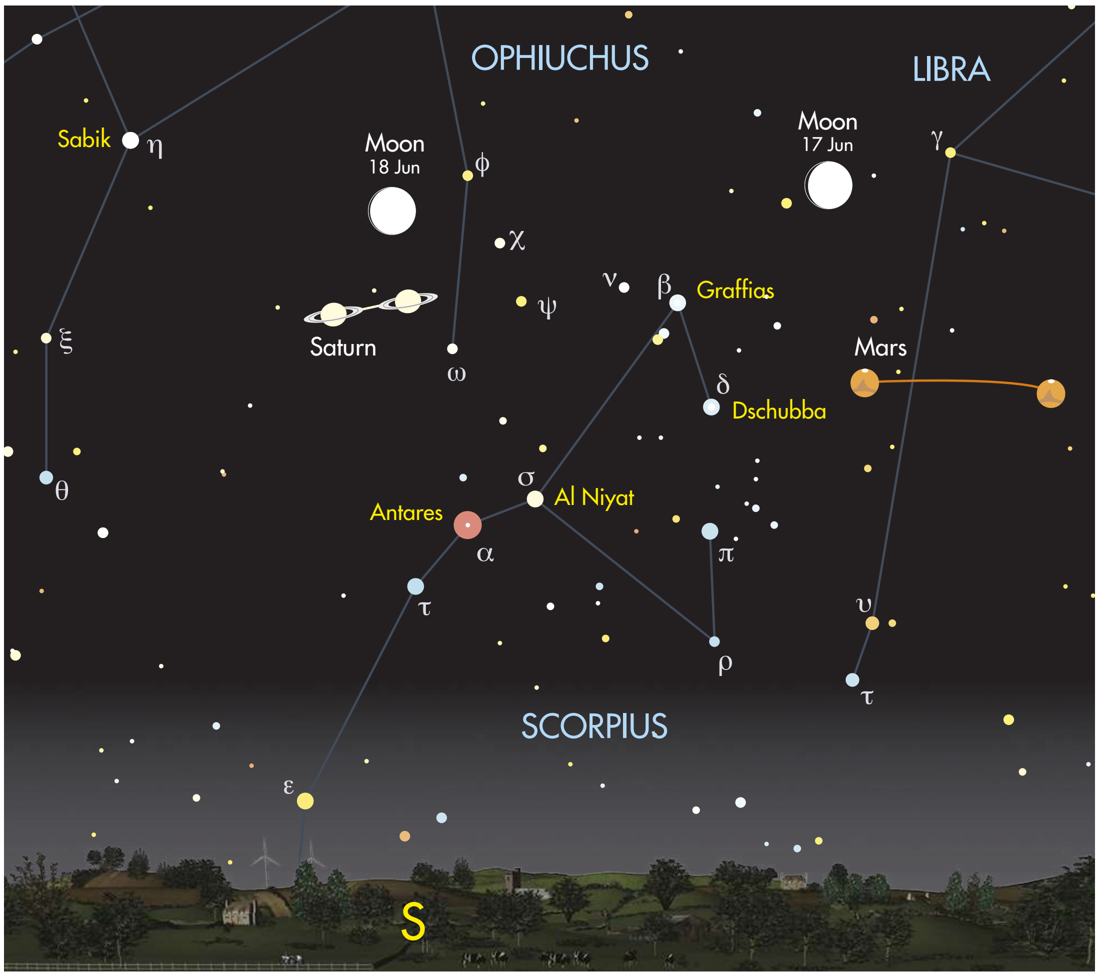
Noctilucent clouds are most often seen in the two hours before sunrise or after sunset

The planets

PICK OF THE MONTH

SATURN

BEST TIME TO SEE: 3 June, 01:10 BST (00:10 UT)
ALTITUDE: 16°
LOCATION: Ophiuchus
DIRECTION: South
FEATURES: Rings, subtle banding, brighter moons, Seeliger effect
EQUIPMENT: 3-inch refractor

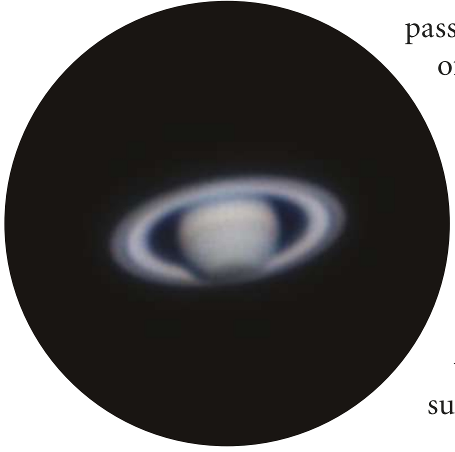


▲ Saturn and Mars currently appear close together low in the south

SATURN REACHES OPPOSITION on 3 June, when it is in the opposite part of the sky to the Sun. Saturn appears slightly brighter and larger when viewed through a telescope at opposition than at other times during the current apparition. Its northern pole is tilted towards Earth by 26° and this gives us a lovely view of the northern face of the rings. During the days around opposition, Saturn's rings can brighten quite noticeably due to the Seeliger effect, and it is well worth making an observation of the planet at opposition and, say, after mid-June to see the difference.

There's no hiding the fact that Saturn is rather low in UK skies at present. Unfortunately there are going to be a few more years of this before things start to improve. The light from a low altitude planet must pass through a thicker layer of atmosphere than when higher up, and this ultimately causes blurring and distortion.

Even so, it is still worth viewing mag. +0.0 Saturn through a telescope. The rings have such a wow factor that even a low-altitude blur can't diminish. A good test of atmospheric stability is to use a medium- to high-power eyepiece to try and see the dark ring separating the outer A ring from the inner B ring. Known as the Cassini Division, this 4,700km 'gap' is actually full of narrow ringlets, invisible from Earth.



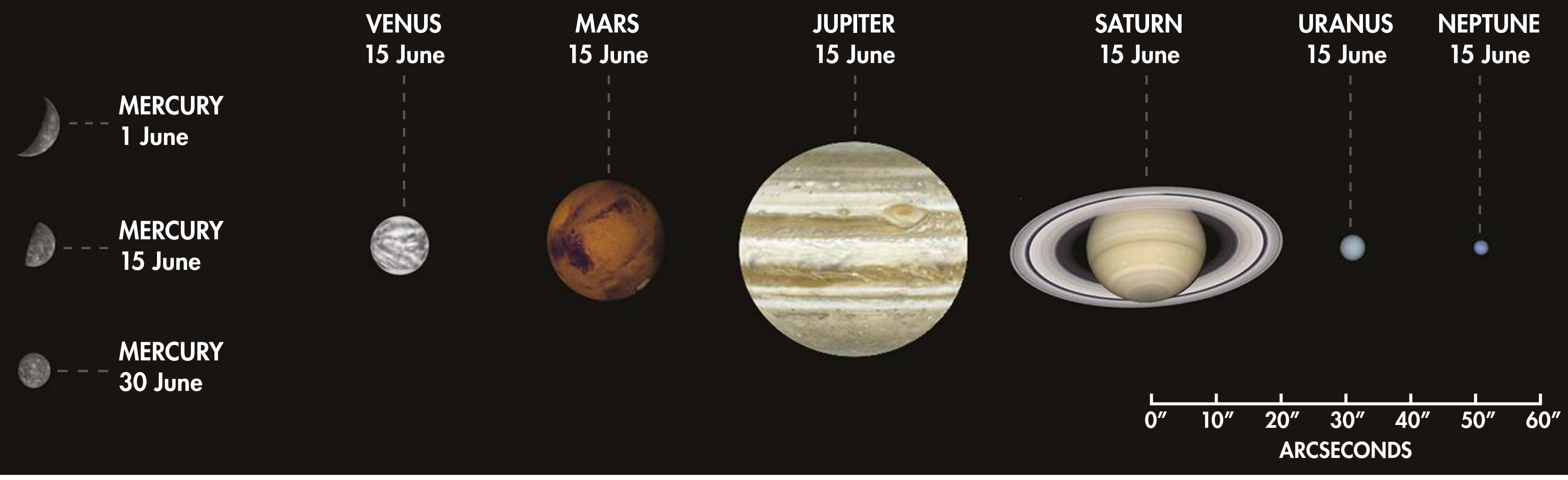
▲ Despite its current low altitude, Saturn's rings are well presented

The planet's globe also has detail in the form of belts, zones and the odd light spot, representing huge storms in the Saturnian atmosphere. These features are far more subtle than those on neighbouring Jupiter. If you're an imager, a good challenge is to try and image the hexagon that surrounds the north pole. This is a strikingly geometric feature that requires good image-scale and seeing to capture well.

PETE LAWRENCE X 3

THE PLANETS IN JUNE

The phase and relative sizes of the planets this month. Each planet is shown with south at the top, to show its orientation through a telescope



MARS

BEST TIME TO SEE: 1 June, 00:00 BST (23:00 UT)
ALTITUDE: 15°
LOCATION: Libra
DIRECTION: South

Well positioned at the start of June, Mars rapidly loses altitude as darkness falls by the end of the month. The planet starts June at mag. –2.0 (the same as Jupiter), but fades to mag. –1.4 by the 30th. Its apparent diameter also wanes as it starts to distance itself from Earth. It reached opposition on 22 May, but was at its closest to Earth for the current apparition on the 30th. Consequently it will appear largest through a scope on 1 June, at 18.6 arcseconds across. This figure will have dropped slightly to 16.3 arcseconds by month end.

If you're lucky enough to get an evening with a relatively still atmosphere, there's plenty of detail still to be seen on Mars. This includes a reasonable view of the planet's north polar region and light wispy atmospheric clouds. The dark V-shaped feature known as Syrtis Major is well placed around midnight during the middle of the month.

JUPITER

BEST TIME TO SEE: 1 June, 23:45 BST (22:45 UT)
ALTITUDE: 22°
LOCATION: Libra
DIRECTION: West-southwest

Jupiter is losing altitude fast by the time the sky starts to darken. The best time to catch it is at the start of the month, when it will appear at its brightest and largest when viewed through a telescope. Catch Jupiter on a night of good seeing and the views can be sublime. The main belts and zones are fairly easy to pick out but patient concentration will allow the finer details to become apparent. The famous Great Red Spot is a long lasting anti-cyclonic storm that, when it's on the Earth-facing side of Jupiter can be seen through a 4-inch scope.

A 45%-lit waxing crescent Moon lies 2.5° below Jupiter as the sky darkens on 11 June. This should be a beautiful sight, both objects hanging in the early evening twilight in the western half of the sky. The planet remains bright all month, being mag. –2.0 on the 1st and only fading to mag. –1.8 by the 30th.

MERCURY

BEST TIME TO SEE: 22 June, 30 minutes before sunrise
ALTITUDE: 2° (low)
LOCATION: Taurus
DIRECTION: Northeast

Mercury reaches greatest western elongation on 5 June. Despite this, it has an unfavourable position in the morning sky.

VENUS

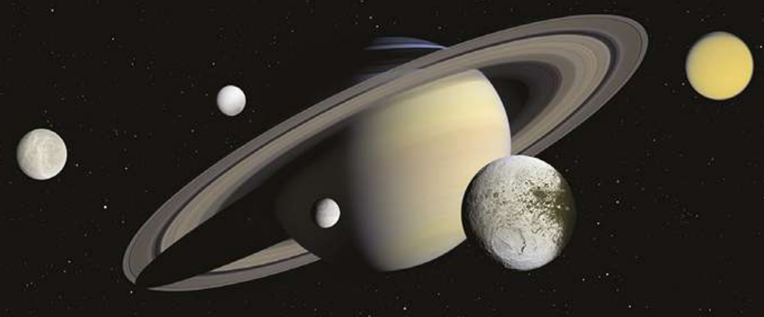
BEST TIME TO SEE: 30 June, 10 minutes after sunset
ALTITUDE: 1.6° (low)
LOCATION: Gemini
DIRECTION: Northwest

After a long, slow approach toward the Sun over the past few months, Venus finally reaches superior conjunction on 6 June. After this time it will change from being a morning object to an evening object. Its re-emergence from the solar glare will be just as slow as its approach, but if you have very clear conditions and a very flat northwest horizon, you might just catch sight of it low down shortly after sunset at the end of the month.

The long, slow re-emergence will definitely be worth the wait. Towards the end of the year and into the start of 2017, the planet will be well separated from the Sun and optimally placed after sunset.

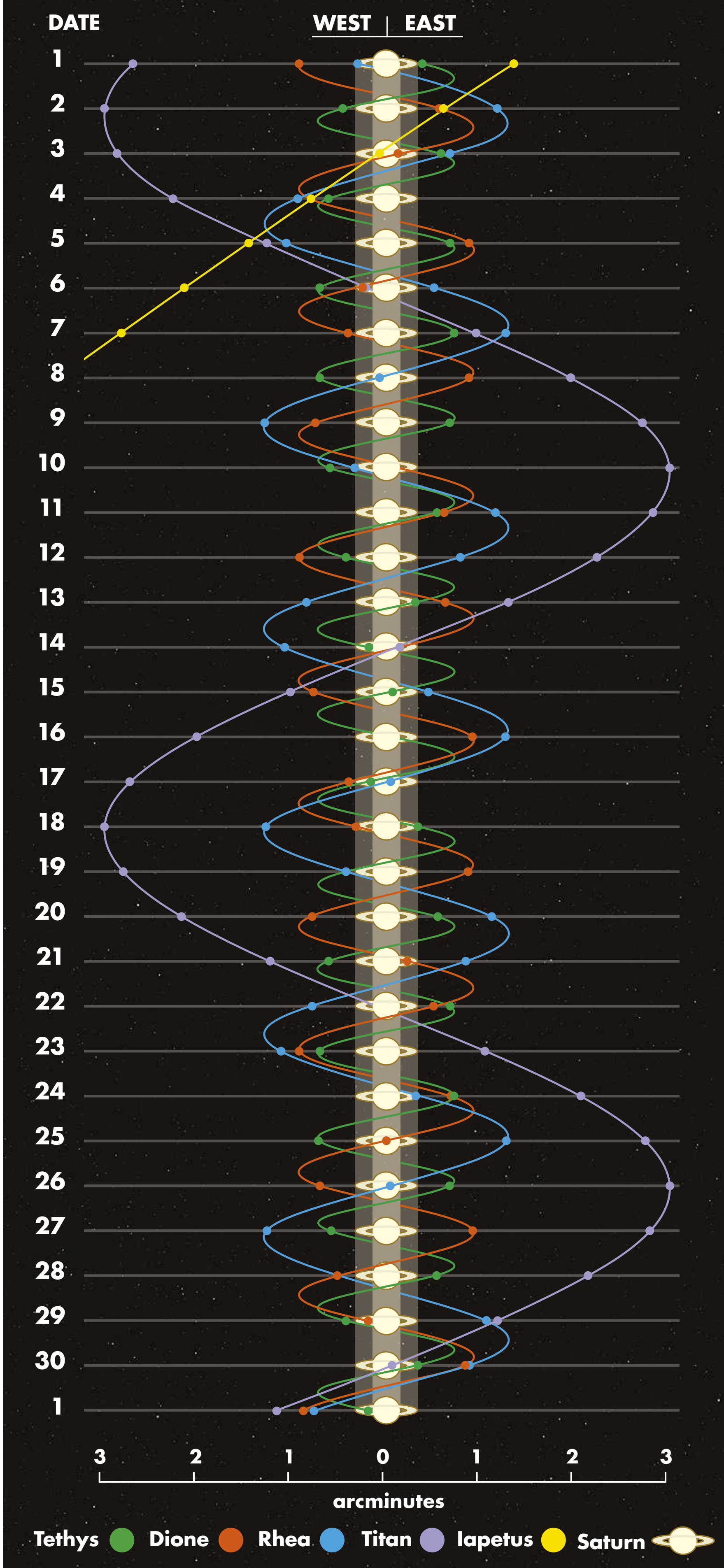
NOT VISIBLE THIS MONTH
URANUS, NEPTUNE

TAP HERE
To see what the planets look like through your telescope with our **field of view calculator**



SATURN'S MOONS
June

Using a small scope you'll be able to spot Saturn's biggest moons. Their positions change dramatically during the month, as shown on the diagram. The line by each date on the left represents 00:00 UT.



The Northern Hemisphere

KEY TO STAR CHARTS

Arcturus	STAR NAME
PERSEUS	CONSTELLATION NAME
⬭	GALAXY
◌ ⁘	OPEN CLUSTER
⊕	GLOBULAR CLUSTER
☼	PLANETARY NEBULA
□	DIFFUSE NEBULOSITY
●	DOUBLE STAR
○	VARIABLE STAR
◐	THE MOON, SHOWING PHASE
☄	COMET TRACK
⋰	ASTEROID TRACK
⋰	STAR-HOPPING PATH
△	METEOR RADIANT
Circlet	ASTERISM
🪐	PLANET
☼	QUASAR

STAR BRIGHTNESS:

●	MAG. 0 & BRIGHTER
●	MAG. +1
•	MAG. +2
•	MAG. +3
·	MAG. +4 & FAINTER
N E W S	COMPASS AND FIELD OF VIEW
	MILKY WAY

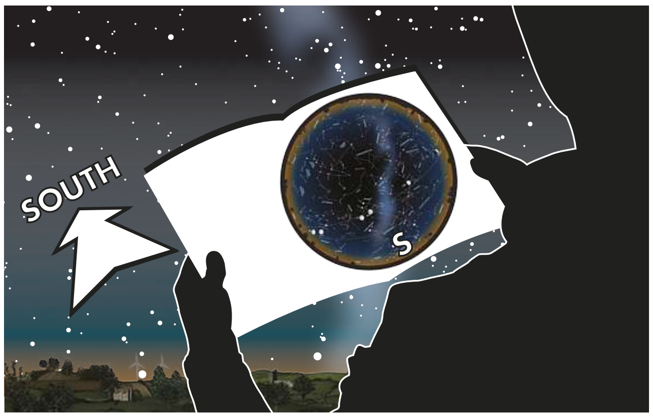
WHEN TO USE THIS CHART

1 JUNE AT 01:00 BST
15 JUNE AT 00:00 BST
30 JUNE AT 23:00 BST

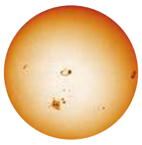
On other dates, stars will be in slightly different places due to Earth's orbital motion. Stars that cross the sky will set in the west four minutes earlier each night.

HOW TO USE THIS CHART

1. **HOLD THE CHART** so the direction you're facing is at the bottom.
2. **THE LOWER HALF** of the chart shows the sky ahead of you.
3. **THE CENTRE OF THE CHART** is the point directly over your head.



THE SUN IN JUNE*



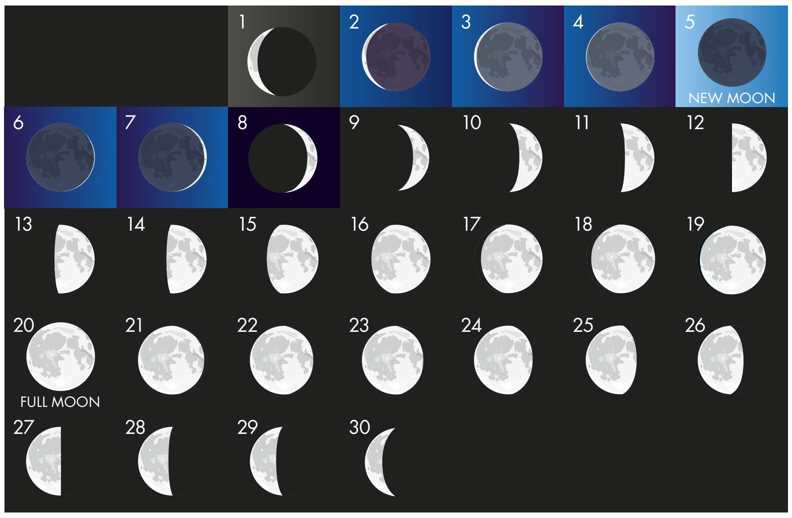
DATE	SUNRISE	SUNSET
1 June 2016	04:47 BST	21:28 BST
11 June 2016	04:41 BST	21:38 BST
21 June 2016	04:41 BST	21:42 BST
1 July 2016	04:46 BST	21:41 BST

THE MOON IN JUNE*

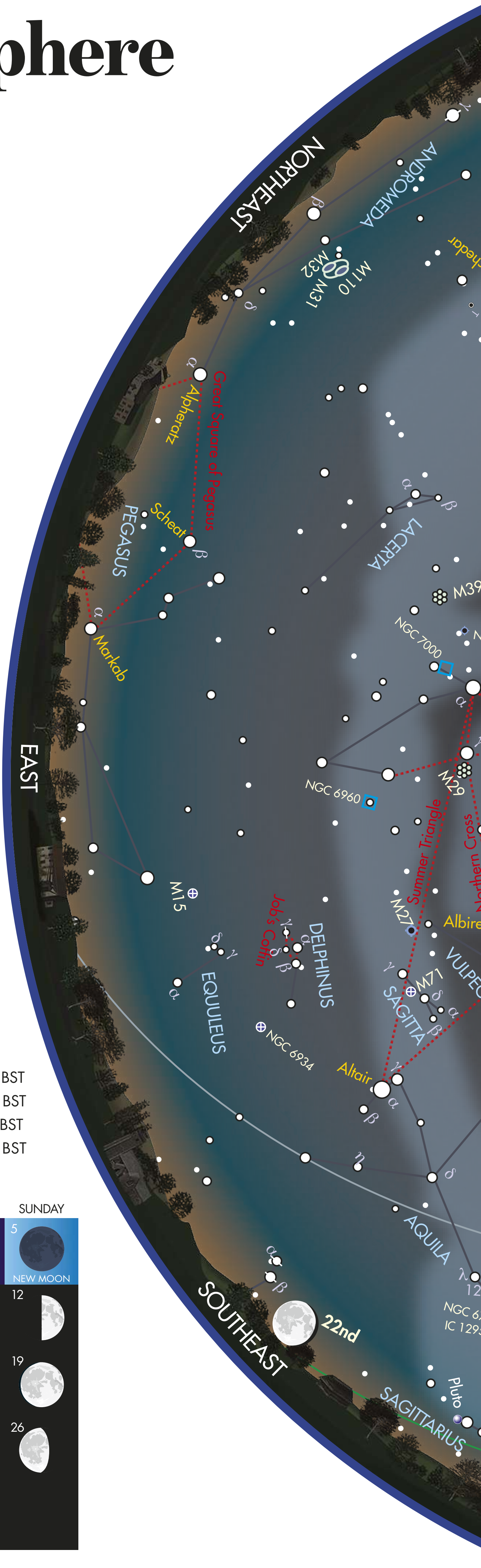
MOONRISE TIMES

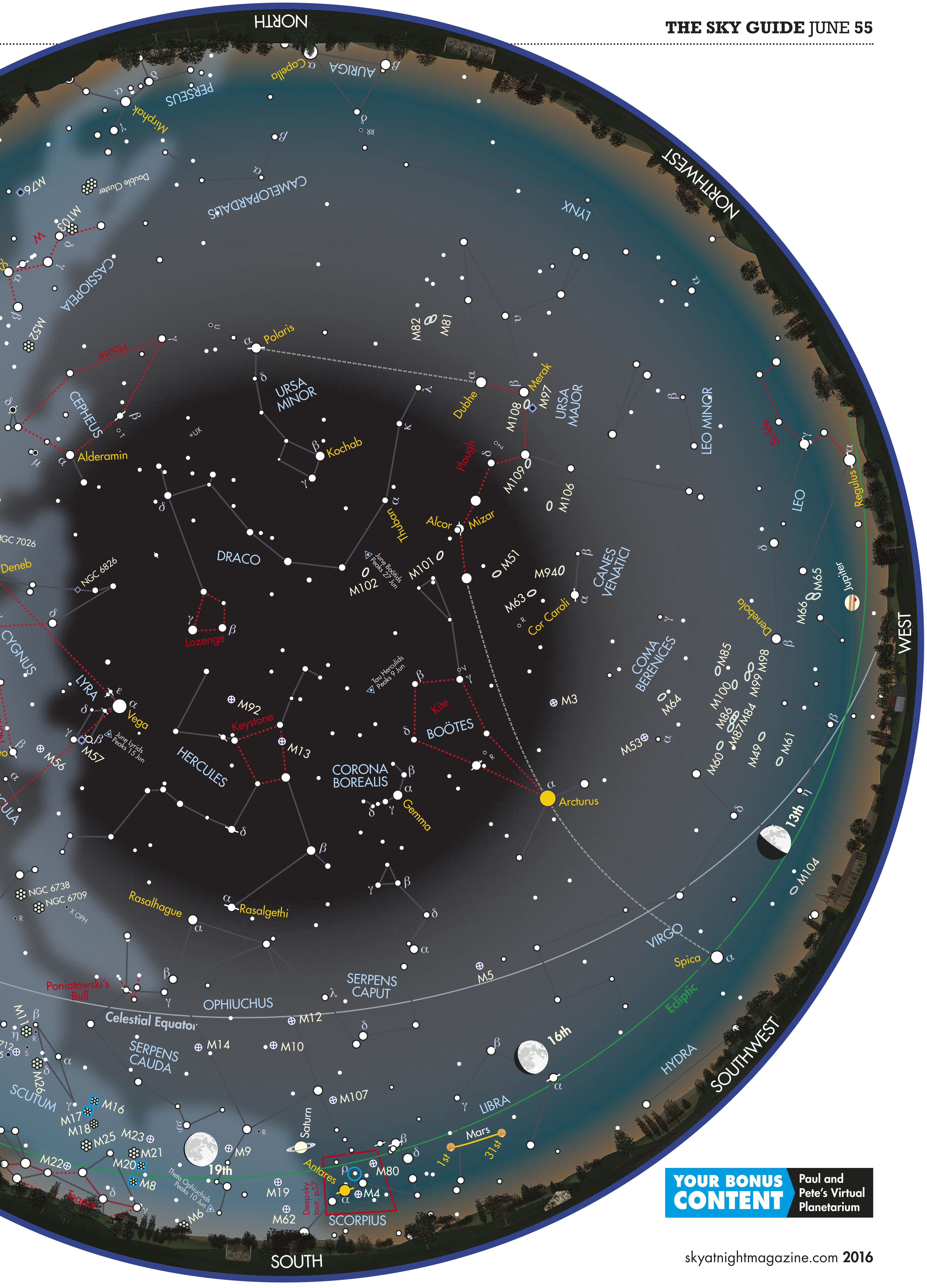
1 June 2016, 03:09 BST	17 June 2016, 18:26 BST
5 June 2016, 05:33 BST	21 June 2016, 22:07 BST
9 June 2016, 09:44 BST	25 June 2016, ––:–– BST
13 June 2016, 14:12 BST	29 June 2016, 01:40 BST

*Times correct for the centre of the UK



MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	SUNDAY
		1	2	3	4	5 NEW MOON
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20 FULL MOON	21	22	23	24	25	26
27	28	29	30			



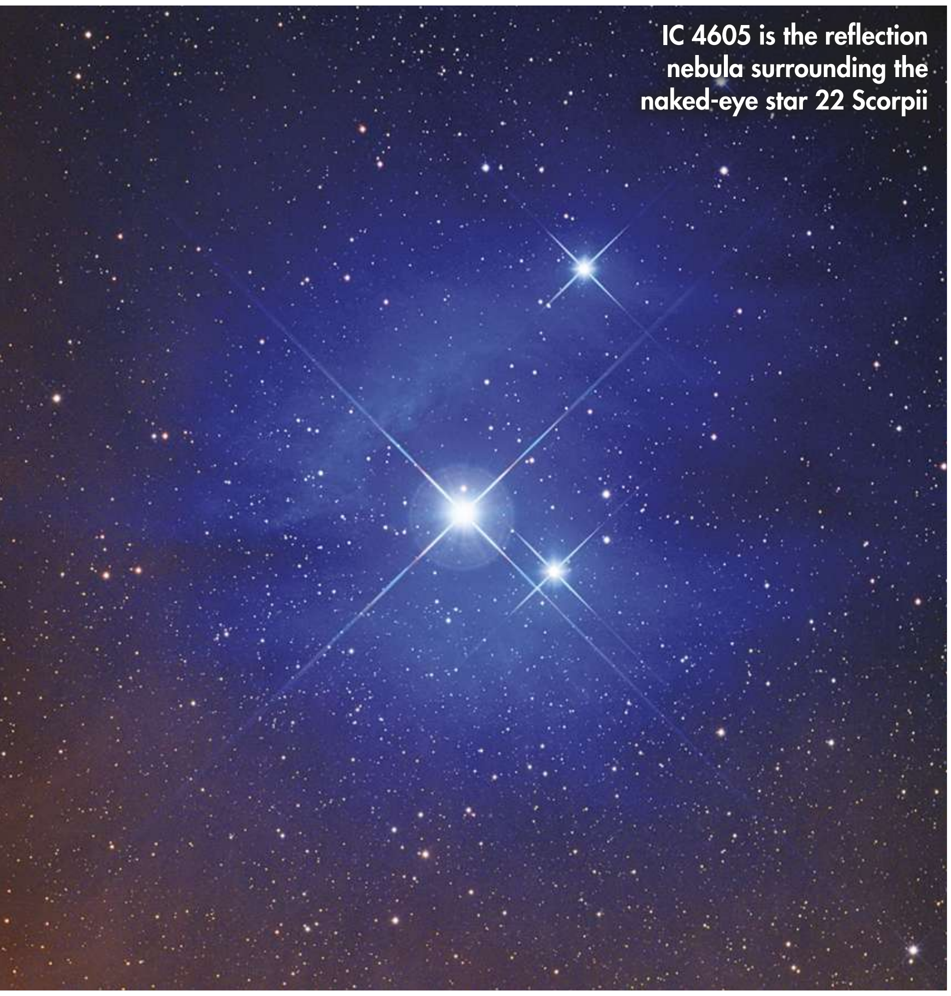


YOUR BONUS CONTENT Paul and Pete's Virtual Planetarium

Deep-sky tour

Swing low over the southern horizon as we take in the heart of Scorpius and its surroundings

☑ Tick the box when you've seen each one



IC 4605 is the reflection nebula surrounding the naked-eye star 22 Scorpii

1

ANTARES

Antares, the alpha star of Scorpius, is a defining star of summer. Its brightness and red/orange colour are hard to miss as it passes east to west, low above the southern horizon. Representing the heart of Scorpius, it makes a great starting point for this month's tour. At mag. +1.0, Antares is an easy naked-eye find. It has a blue-white mag. +5.4 companion lying 2.5 arcseconds to the west which, considering its low UK altitude, is challenging to see. An 8-inch or larger scope at 250-300x magnification should split them on a night of good to excellent seeing. The companion is often described as green due to the colour contrast between it and red supergiant Antares. ☐ **SEEN IT**

2

M4

Beautiful, mag. +5.9 globular cluster M4 lies 1.3° west of Antares and is a fine sight in a telescope of any size. A 6-inch scope will show M4's core to be rather irregular in brightness. One characteristic feature here is a line of slightly brighter stars that runs north-south across the core. An 8-inch scope and 250x magnification will easily resolve the cluster, showing it to be around 10 arcminutes across. M4 contains a number of white dwarf stars determined to be around 13 billion years old. This makes them amongst the oldest stars in the Milky Way galaxy. ☐ **SEEN IT**

THIS DEEP-SKY TOUR HAS BEEN AUTOMATED

ASCOM-enabled Go-To mounts can now take you to this month's targets at the touch of a button, with our Deep-Sky Tour file for the EQTOUR app. Find it online.

M79; Globular Cluster
IC418; Spirograph Nebula
NGC 2232; Open Cluster
M42; Great Orion Nebula
M78; Nebula
Meissa; Lambda Orionis

Altitude: 0 Deg
Mag: None
Object RA/DEC: 00:00:00 hr 00:00:00 deg
Object Az/Alt: 74:42:03 deg -12:06:07 deg
Scope RA/DEC: 22:42:19 hr 90:00:00 deg

3

NGC 6144

Although M4 takes the lion's share of attention, there are many other globular clusters nearby. Located 37 arcminutes northeast of Antares is the 9th-magnitude globular NGC 6144. It lies 33,000 lightyears from Earth, a little over three times the distance of M4. A 6-inch scope will not show much more than a faint glow, although high magnifications may suggest a mottled texture. A 10-inch scope fares better, revealing an object approximately one-third the size of M4. Some cluster stars will resolve at 150x magnification. Increasing aperture to 12 inches doesn't bring much additional resolution, although the cluster's apparent size will increase slightly to around 4 arcminutes across. ☐ **SEEN IT**

4

IC 4605

When you look at the region north of Antares, you're looking into a part of the Milky Way that is quite close to our Galaxy's core. Consequently, there are some wonderful 'local' galactic objects to be seen here such as IC 4605. This is a reflection nebula surrounding the mag. +4.8 star 22 Scorpii, which is located 1.3° north of Antares. It is part of a vast collection of beautifully coloured nebulae, collectively referred to as the Rho Ophiuchi Complex. Visually the colours will be absent, but if you look directly at 22 Scorpii with a large instrument it is just about possible to see that the star has a glowing halo around it. This is IC 4605. ☐ **SEEN IT**

5

IC 4604

The star that gives the Rho Ophiuchi Complex its name is unsurprisingly Rho (ρ) Ophiuchi, located 3° north and a fraction west of Antares. It initially looks like a mag. +4.6 star, but high power reveals two blue-white components separated by just 3.1 arcseconds. Point a large telescope at Rho Ophiuchi using a low-power eyepiece and a couple of additional 7th-magnitude stars can be seen; one north and one west-southwest. With good, dark skies, a gentle glow appears to encompass Rho Ophiuchi and these stars, the brightness being most evident around Rho Ophiuchi itself. ☐ **SEEN IT**

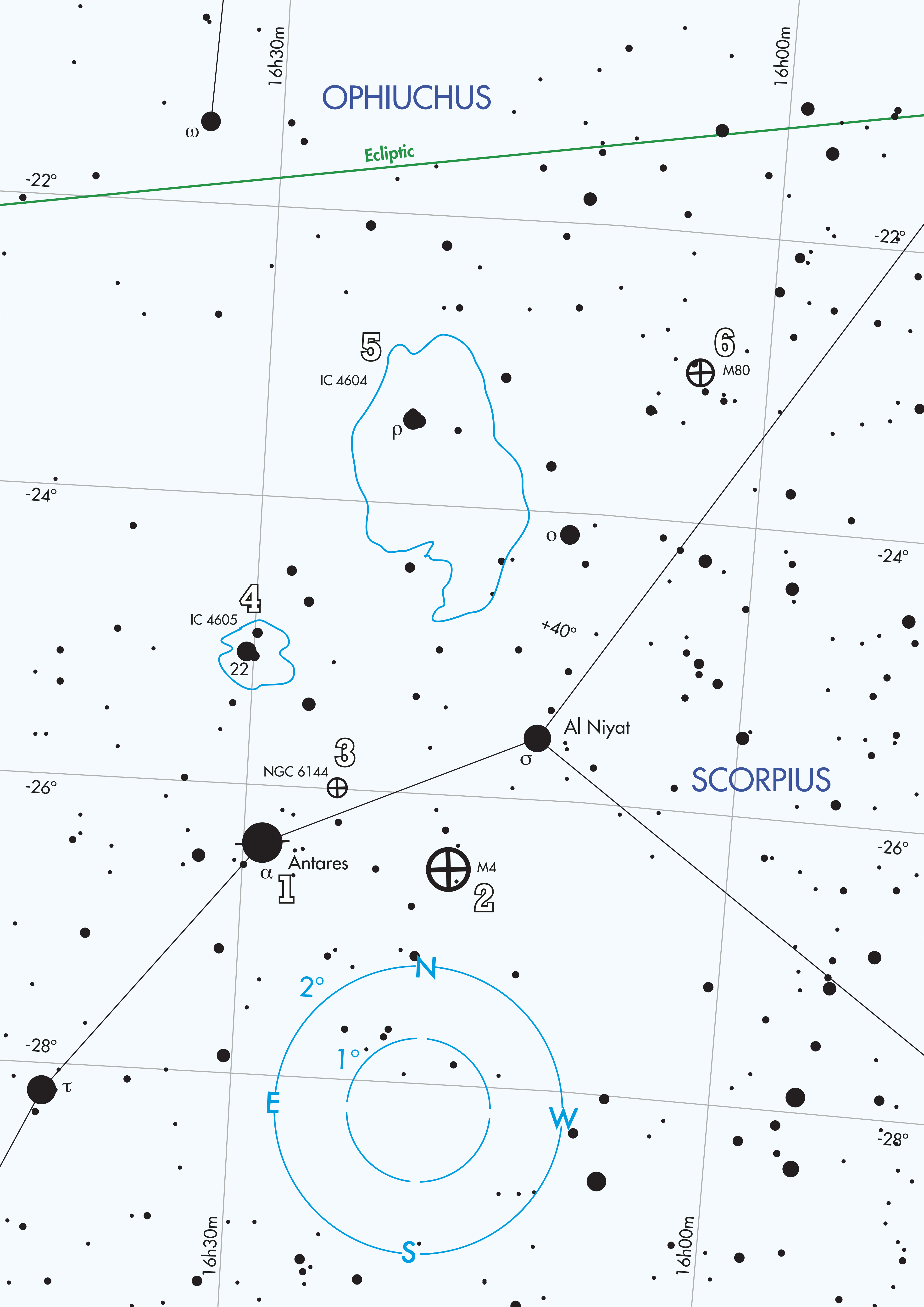
6

M80

We end our low southern sky tour 2° west and slightly north of Rho Ophiuchi. Here you'll find another globular cluster known as M80. This is a 7th-magnitude object that can be easily seen in any size of telescope. It's a compact and well-defined globular, which shows granularity around its outer edges in a 6-inch scope at high magnification. A 10-inch instrument at 250x magnification improves the view and goes some way to resolving part of the core. A mag. +8.4 star lies 5 arcminutes northeast of M80's centre, and another mag. +8.7 star is 8 arcminutes to the south. A 12-inch scope will resolve the entire cluster. ☐ **SEEN IT**

YOUR BONUS CONTENT Print out this chart and take an automated Go-To tour

CHART: PETE LAWRENCE, PHOTO: GERALD RHEMANN/CCDGUIDE.COM


OPHIUCHUS
SCORPIUS
Ecliptic
16h30m
16h00m
-22°
-24°
-26°
-28°
ω
5
IC 4604
ρ
6
M80
o
+40°
4
IC 4605
22
3
NGC 6144
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Antares
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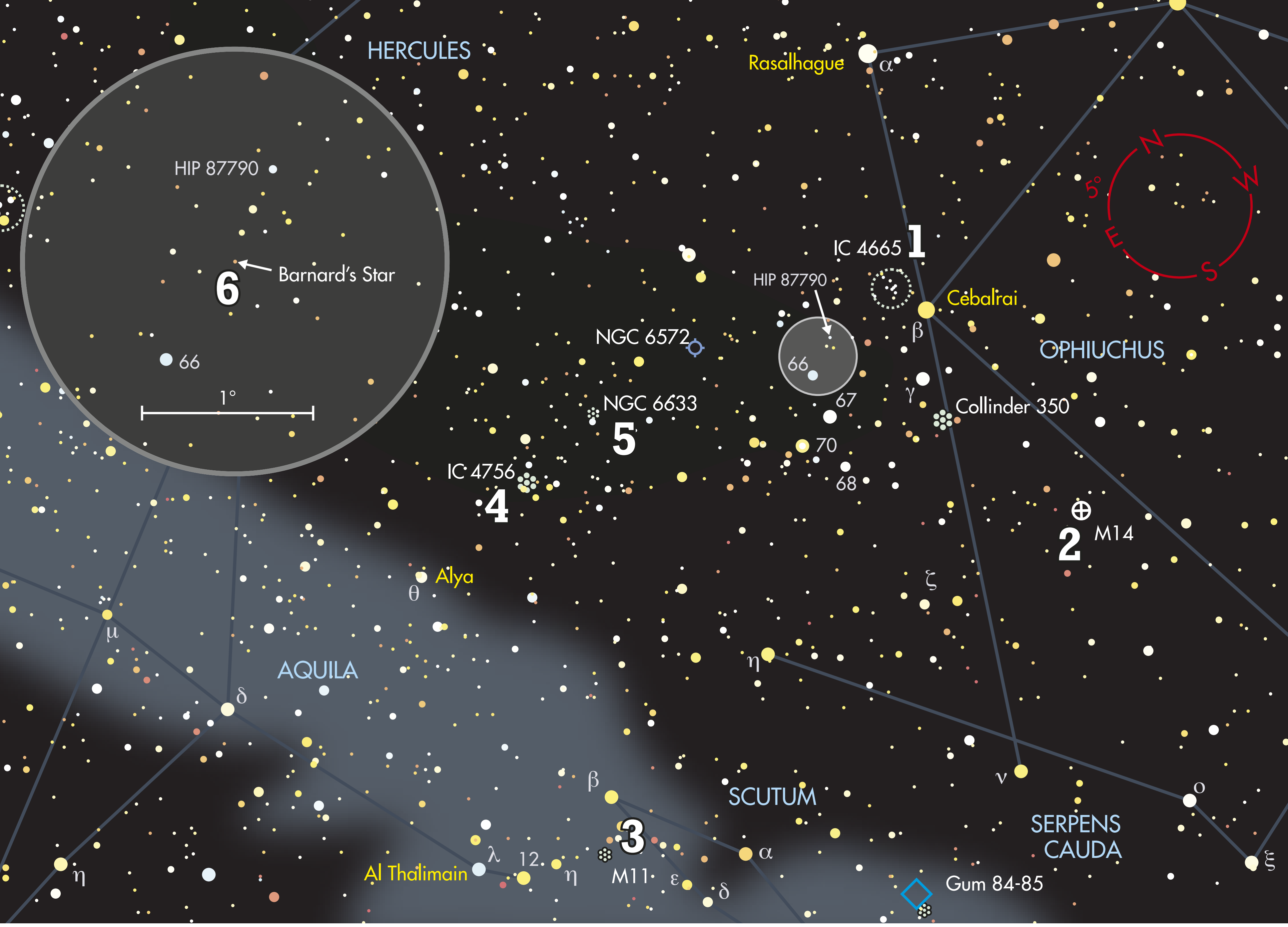
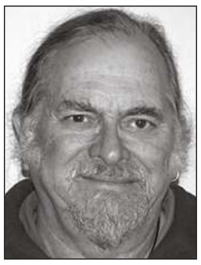




Binocular tour

A welcoming cluster, a stellar sprinter and diamond dust litter the June night skies

With
Stephen Tonkin

☑ Tick the box when you've seen each one

1 THE SUMMER BEEHIVE

10x50 Our first object welcomes us to the summer skies, with its brighter stars forming the word "HI". The Summer Beehive, an open cluster designated IC 4665, sits in the same field of view as mag. +2.7 Cebalrai (Beta (β) Ophiuchi). It is a lovely sight in binoculars of any size and you should be able to resolve a dozen stars with a pair of 10x50s, including the delightful curved chain of hot white stars that forms part of the letter H. The cluster is 1,400 lightyears away and relatively young at less than 40 million years old. ☐ **SEEN IT**

2 M14

15x70 Mag +7.6 globular cluster M14 requires 15x70s. It is approximately 6° west of mag. +4.6 Zeta (ζ) Serpentis and is a moderately easy object, even in June's all-night twilight. Try using averted vision on it; it should appear to grow in size and show a slight brightening of the core. Mounted binoculars may also reveal a slightly triangular appearance, which is an optical illusion that is caused by faint strings of stars that seem to run from the southeast and southwest peripheries of the cluster. ☐ **SEEN IT**

3 THE WILD DUCK CLUSTER

10x50 Mag. +5.8 M11, the Wild Duck Cluster, lies 2° southeast of the mag. +4.2 Beta (β) Scuti. In 10×50 binoculars, this open cluster appears as a bright and slightly wedge-shaped glow, and could initially be mistaken for a globular. It is one of the better objects for small binoculars, although they will not resolve the V of brighter stars that gives M11 its common name. The Scutum Star Cloud, the huge dense part of the Milky Way that forms a backdrop to the Wild Duck, is a lovely binocular target in its own right. ☐ **SEEN IT**

4 GRAFF'S CLUSTER

10x50 From M11, pan 10° north to mag. +4.6 Alya (Theta (θ) Serpentis), and from there 4.5° in the direction of mag. +2.0 Rasalhague (Alpha (α) Ophiuchi). Here you will find a softly glowing patch of light, just over 1° in diameter. This is Graff's Cluster, IC 4756, an enormous grouping of stars is approximately 1,300 lightyears distant and more than 20 lightyears across. If you are patient and use averted vision, you might experience the common description of it as being "brighter stars, scattered over a background of diamond dust". ☐ **SEEN IT**

5 NGC 6633

10x50 Pan another 3° towards Rasalhague and you should find NGC 6633, a lovely little cluster often overlooked in lists of binocular targets because it can be tricky to find. It is easily visible in a pair of 10x50s with the four brightest stars shining against the elongated glow of the fainter members of the cluster. It is interesting to compare it to Graff's Cluster, which fits in the same field of view. NGC 6633 not only looks smaller and more compact; it is smaller and more compact, being slightly closer at 1,040 lightyears. ☐ **SEEN IT**

6 BARNARD'S STAR

15x70 Barnard's Star is the star with the greatest proper motion (apparent motion relative to the celestial sphere). Although it is easiest to see from the UK in the summer, it is only 9th magnitude, so it can be a challenging target in skies that don't get properly dark. Begin at mag. +4.8 66 Ophiuchi and centre it in your field of view. Use the inset chart to locate Barnard's Star, which is 0.7° away from 66 Ophiuchi. Using binoculars, it will take you a decade or so to detect its apparent motion. ☐ **SEEN IT**

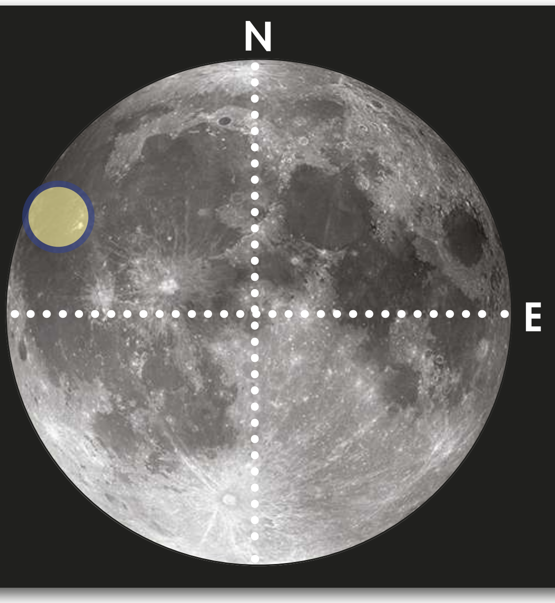
CHARTS AND PICTURES: PETE LAWRENCE

Moonwatch

Schiaparelli

STATISTICS

TYPE: Crater
SIZE: 25km
AGE: 3.2-3.9 billion years
LOCATION: Latitude 23.4°N, longitude 58.8°W
BEST TIME TO OBSERVE: Five days after first quarter or four days after last quarter (1-2 June around 04:00 BST and 17-28 June)
MINIMUM EQUIPMENT: 2-inch telescope



NESTLED BETWEEN THE bright 43km-diameter crater Aristachus and remains of lava-flooded 40km Seleucus, in the northern region of Oceanus Procellarum, is the small (25km) and fairly insignificant crater Schiaparelli. It is named after Giovanni Virginio Schiaparelli, a skilled Italian astronomer and science historian who observed and named the 'seas' and 'continents' on Mars.

Observing Mars during the Great Opposition of 1877, he recorded and sketched many dark linear features which he labelled 'canali' meaning 'channels'. Unfortunately, this term was incorrectly translated to English as 'canals', giving rise to the presumption that the features were artificial rather than natural. The inference here was that Martians had built them. He is also credited with the discovery of asteroid 69 Hesperia, and showed that the annual Perseid and Leonid meteor showers were associated with comets. His rather small presence on the lunar surface is perhaps more fittingly addressed on Mars, where crater Schiaparelli spans 461km.

Although the lunar Schiaparelli is much smaller, it is still very interesting. It appears circular and embedded into the Oceanus Procellarum's floor; lava from Procellarum seems to have flowed over the crater's ejecta blanket. The crater is estimated to be 2,000m deep, with a rim that rises 600m above the surrounding lava.

This rim is sharp and well defined, and leads down to a relatively unscathed floor that is free from any noticeable subsequent impacts. As craters go, Schiaparelli is remarkably untouched considering its estimated age of between 3.2 and 3.9 billion years; it seems there are some advantages to being small on the Moon! The crater possesses a relatively small central mountain, which is surrounded by some low lying hills but these features aren't prominent by any stretch of the imagination.

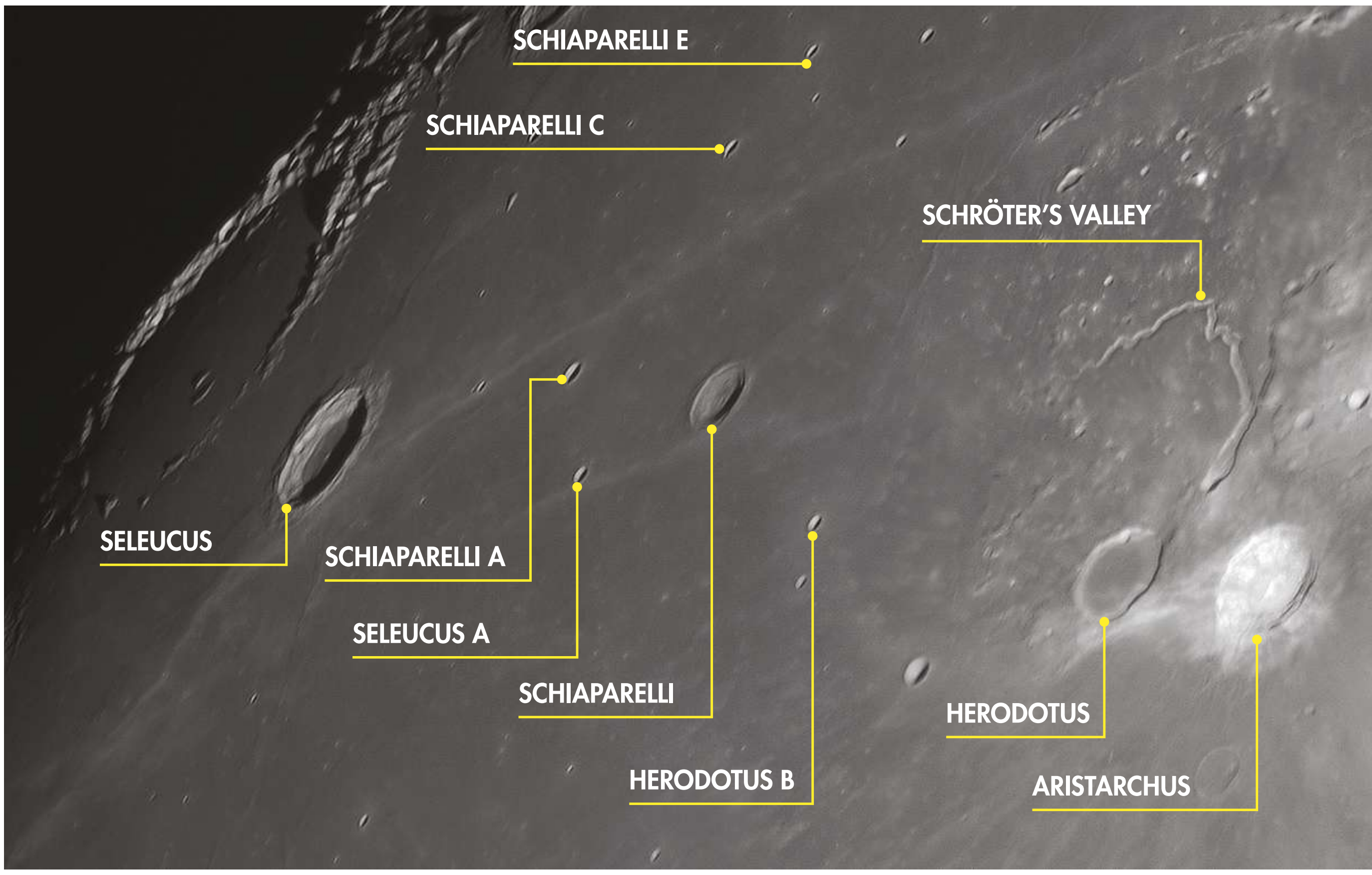
A light ejecta ray passes over the floor of Procellarum just to the south of Schiaparelli. This is from the 40km ray crater Glushko, located 680km to the southwest. A meandering ray that passes to the north of Schiaparelli also emanates from the same region. This more prominent ray passes just south of Seleucus, 240km away. Two small craterlets lie between Schiaparelli and Seleucus, the southern one being 6km Seleucus A, the northern one 7km Schiaparelli A.

"As craters go, Schiaparelli is remarkably untouched considering its age"

To the east is the unmistakably bright crater Aristarchus, the brightest feature on the near side of the Moon. Adjacent to it is the Aristarchus plateau; an elevated region full of volcanic features. Schröter's Valley, a sinuous rille, can be seen here.

West of Aristarchus is flat-floored crater Herodotus (35km). At one time, before being selected as an official IAU named lunar formation, Schiaparelli was known as Herodotus C. This explains why the small 6km craterlet located to the southeast of Schiaparelli is Herodotus B, despite its primary being nearly twice as far away as Schiaparelli.

Two further satellite craterlets can be found north of Schiaparelli. These are 6km Schiaparelli C, 112km away, and 5km Schiaparelli E, 140km away. Schiaparelli E is a good test for a 4-inch scope. Under direct illumination close to full Moon, the small craterlets are somewhat easier to locate than Schiaparelli itself.



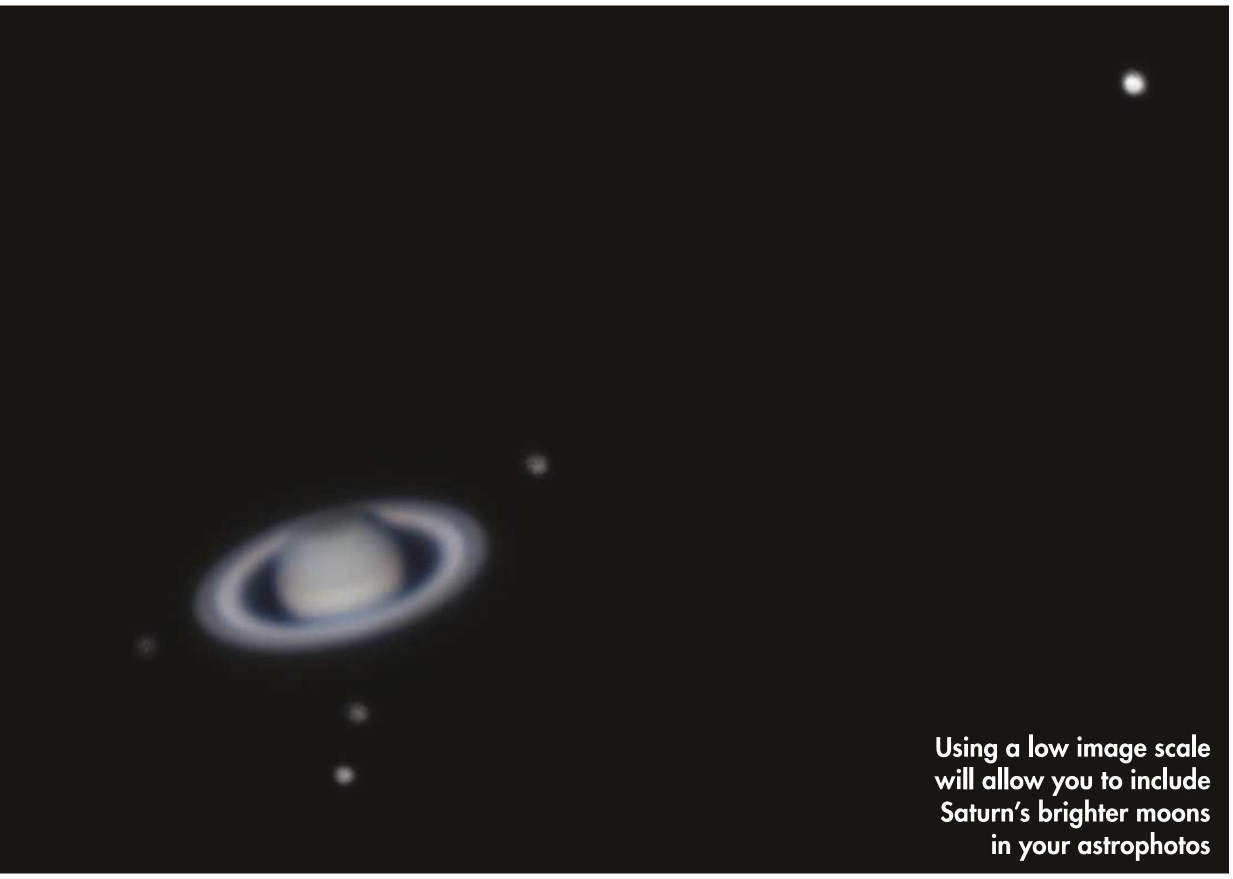
▲ Schiaparelli hasn't always been a IAU-recognised crater in its own right; it was once a satellite of Herodotus

Astrophotography

Imaging Saturn

RECOMMENDED EQUIPMENT

8-inch or larger telescope, high frame rate camera (either monochrome with RGB-IR filters or colour with an atmospheric dispersion corrector)



Using a low image scale will allow you to include Saturn's brighter moons in your astrophotos

SATURN IS A truly beautiful planet. Its main attraction is its rings, and these more than make up for the fact that the planet's globe is less visually dynamic than its inner neighbour Jupiter. Having said this, Saturn's globe can have its moments and detail typically appears as light spots which move as the planet rotates on its axis.

The rings are quite magnificent, presenting a different aspect each apparition as the planet passes around its 29.5-year orbit. Currently, the rings appear opened up, tilted over by 26º. This gives us a great opportunity to examine them in detail.

The outer ring is known as the A ring and appears dimmer than the inner B ring. With good conditions it is obvious that the B ring isn't the inner one at all, as there's a further inner ring known as the C ring. A narrow, dark line divides the A and B rings; this is the famous Cassini Division, once thought to be a 4,800km gap in the ring system, but now known to be full of narrow ringlets in its own right.

The Cassini Division is often used as a means to determine the quality of the view. Under poor seeing conditions it can 'fuzz out' completely and be really hard to see and image. Under good seeing conditions, its dark contrast makes it a wonderful focus target.

Although seeing doesn't work in favour of Saturn when it's so low down in the sky, it's important not to bring down the shutters and dismiss the planet completely. Under certain conditions, the seeing can stabilise enough to give you a decent look. It's just that at low altitude the probability of this happening is lower than if the planet were higher in the sky. It certainly doesn't mean it can't happen though.

Vigilance is the name of the game here as well as keeping an eye on the weather forecasts, looking out for calm and stable conditions. A high pressure is often good for this. Observing Saturn after an active front has just passed through is unlikely to net you good results.

The jet stream's position is important too. This corridor of fast moving air adds yet another layer of turbulence to the view. However, although it seems to love passing over the UK, it sometimes wanders off. Keeping an eye out for when the jet stream is absent will at least allow you to choose a night when one seeing hurdle has been removed.

You might be lucky enough to get some excellent seeing at low altitude, but more than likely, it'll be just okay. If this happens, then it's important not to pile on too much power. If you do, all you'll be doing is magnifying the atmospheric distortions, reducing contrast and dimming the image and the net result will probably not look that great.

Lowering the magnification should give a brighter and cleaner-looking result. It may lack the overall pizazz of a large image-scale Saturn, but at least it'll be showing those beautiful rings off to best effect. As a bonus, reducing the image scale will often allow you to include some of Saturn's brighter moons. For a low Saturn, the saying 'less is more' definitely applies – sometimes at least.

KEY TECHNIQUE

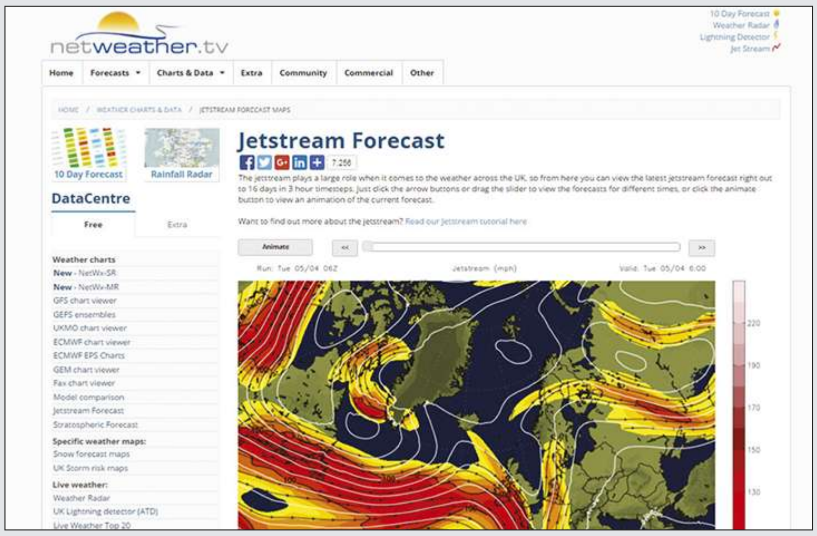
DEALING WITH ALTITUDE

There's no denying that Saturn is very low down. This means its light will be passing through a thicker layer of normally quite turbulent atmosphere and this will both dim and distort the view you get. Use the appropriate image scale for the conditions. Too much and you'll just get a better view of the distortions. Low image scale also helps maintain the planet's brightness on chip, which helps achieve decent exposure.

Send your image to: hotshots@skyatnightmagazine.com

ALL PICTURES: PETE LAWRENCE

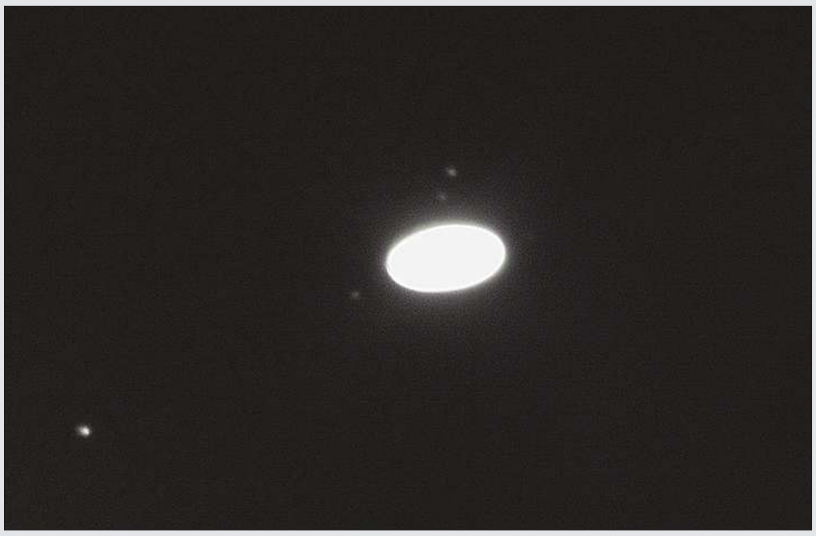
STEP-BY-STEP GUIDE



The jetstream plays a large role when it comes to the weather across the UK, so from here you can view the latest jetstream forecast right out to 16 days in 3 hour timesteps. Just click the arrow buttons or drag the slider to view the forecasts for different times, or click the animate button to view an animation of the current forecast.

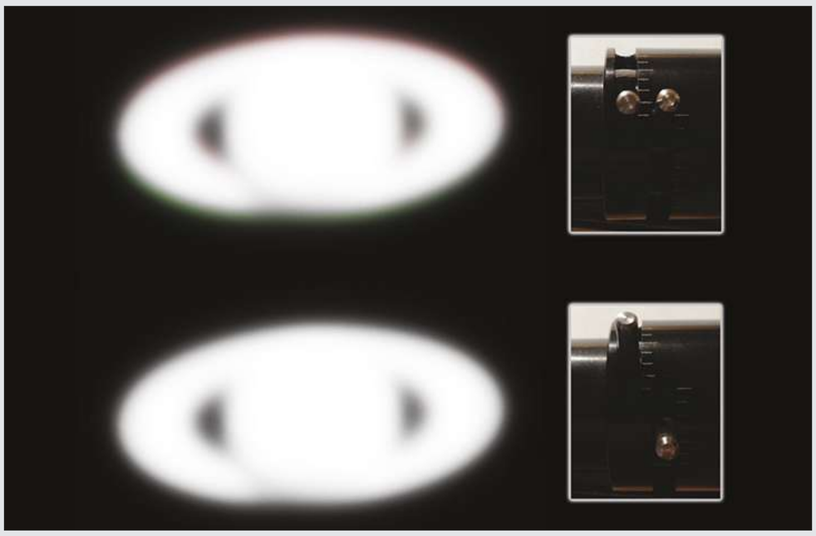
Want to find out more about the jetstream? Read our Jetstream tutorial here

STEP 1 Atmospheric seeing is caused by blobs of air or different temperatures and densities passing between you and your target. It's multi-layered, with the highest component due to the jet stream. Check the latest jet stream forecast using an online service such as NetWeather. If the jet stream is clear of the UK, this is a good sign.



STEP 2 Image scale describes how large an object appears in your image. It can be increased using a Barlow lens or reduced by using a focal reducer. Adjust the scale until Saturn appears recognisable without too much atmospheric distortion. Up your camera's sensitivity until the moons can be seen; they should be reasonably point like.

STEP 3 Imaging with a colour high frame rate camera gives you a brighter signal than if using a mono camera and RGB filters. However, atmospheric dispersion has a big effect on low planets imaged in colour. Using an atmospheric dispersion corrector (best suited to high image scales) provides a means for atmospherically separated colours to be recombined.



STEP 4 To use an ADC, the zero position of its prism adjustment levers must align with the horizontal. For an equatorial mount, this means periodically adjusting the orientation. Boost the camera's gain/exposure until the planet overexposes. This should reveal any colour fringes. Slowly separate the levers until the fringes disappear.

STEP 5 Mono cameras with RGB filters can also benefit from an ADC, but if conditions require a small image scale non-ADC captures should be fine. Refocus between filters, taking your time as you do so. Poor seeing can cause a focused image to temporarily blur, so monitor carefully before deciding on the final focus position. An electric focuser makes things easier by removing the scope shake induced by touching the focus knob.

STEP 6 Seeing is typically worse for shorter wavelengths, so blue is affected more than red. An infrared-pass filter fitted to a mono high frame rate camera with good infrared sensitivity may allow for a better capture than individual colour filters. The problem with this approach is that the filter will tend to dim the image, which may lead to a lower frame rate.

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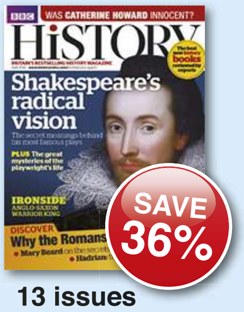
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MORE AMAZING ASTRO IMAGES IN IAPY 2016

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THE COSMOS IN YOUR POCKET

Not all astrophotography requires an expensive camera. As **Pete Lawrence** explains, the smartphone you carry every day can be used to capture a range of night-sky objects

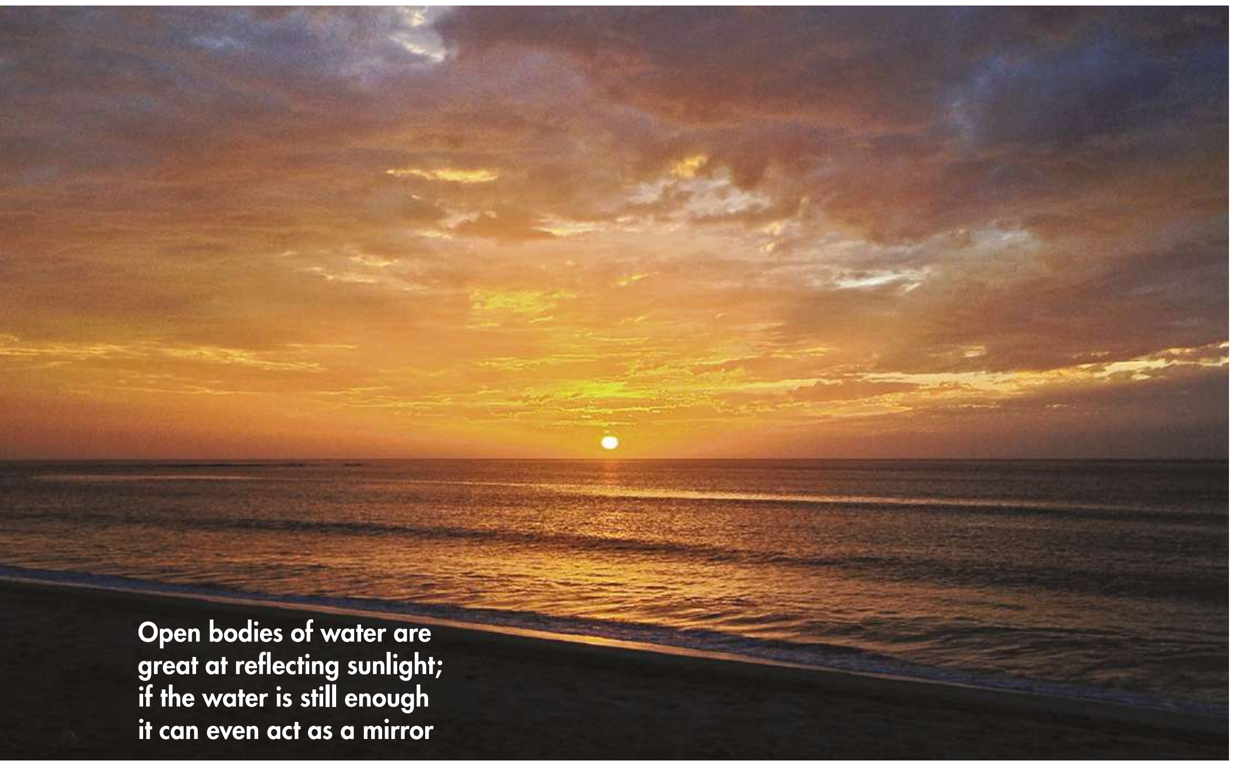
Astrophotography with just a phone camera may sound a bit far-fetched, but there are certain subjects that can be captured in this manner. Here we've got suggestions for some brighter subjects to start you off, with a gentle push towards more challenging targets. Some devices are better at this than others, the most successful being the ones that offer good manual control over exposure, ISO and (most importantly) focusing. Since phone cameras vary significantly in capability, we've also included a few tricks to help you overcome some of the hurdles you may encounter. ▸

ISTOCK

ABOUT THE WRITER
Pete Lawrence is an astrophotographer with a particular interest in digital imaging. He appears on *The Sky at Night* each month.

SUNSET/SUNRISE

To catch the Sun as its best, wait until it is hovering close to the horizon


Open bodies of water are great at reflecting sunlight; if the water is still enough it can even act as a mirror

THE PERIODS AROUND sunrise and sunset provide a fairly easy target for many smartphone and tablet cameras, as both the sky and landscape below are sufficiently well lit to allow the camera's auto functions to react without too much difficulty. Some sunrises and sunsets are better than others, and clouds can actually enhance the scene as they reflect the reddened light of a low Sun. The shadows cast by clouds into the atmosphere can give rise to crepuscular rays, a phenomenon that makes it look as if dark rays are spreading out from the Sun. These can be pretty spectacular and, amazingly, only appear to emanate from the Sun due to perspective. They are actually parallel to one another.

The rising or setting Sun can appear to be larger than it does when high up (not that it's advisable to look directly at the Sun of course), but this is an illusion. Using a camera, an apparently large red Sun will still photograph small. Smartphones cope with the bright Sun in different ways according to model and make. If the camera's auto functions deliver a large white blob where the Sun was located, then there's not much you can do with this in post-processing. However, if you have an app that lets you take control of the phone's camera settings then it may be possible to reduce sensitivity (ISO), aperture and exposure to reduce this effect.

Many smartphones come with a high dynamic range (HDR) capability. If yours has this, turn it on and, if available, set it to save both the original shot and HDR shot. HDR basically delivers an image with an extended tonal range to deal with both bright and dark portions of a scene. Once photographed, there are third-party apps that can be employed to bring out even more detail, but be careful here as it's very easy to step over the line and produce something that looks quite unnatural.

NEXT STEPS...

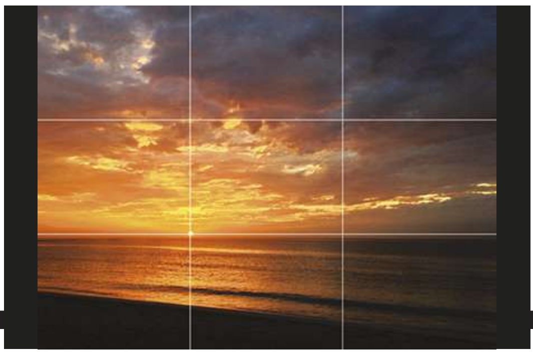
Consider the foreground. Silhouetted objects, people or birds will often add another dimension to sunrise or sunset photographs. Similarly, a body of foreground water can produce some superb effects, especially if flat enough to reflect the main sunrise or sunset scene.

HELPFUL APPS

SnapSeed (iOS; free)
HDR (iOS; £1.49)
Camera HDR Studio (Android; £1.71)
HDR Camera (Android; free)

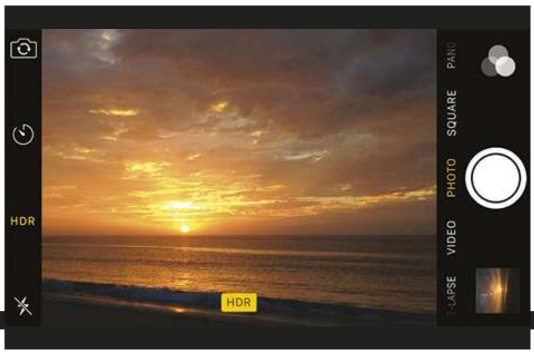
Three steps to snapping a dramatic shot of the Sun in splendour

ALL PICTURES: PETE LAWRENCE



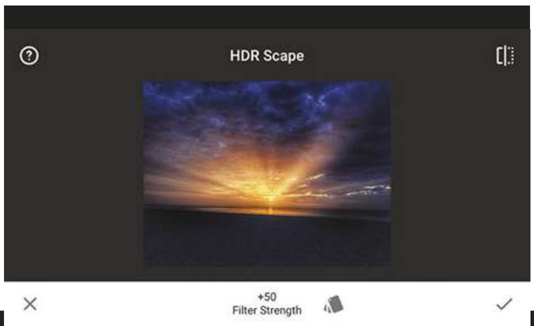
STEP 1

A colourful sunset or sunrise will give the best results. If possible shoot with the Sun above the horizon but dimmed behind cloud. Frame the shot to include one-third of the horizon, preferably in a landscape orientation.



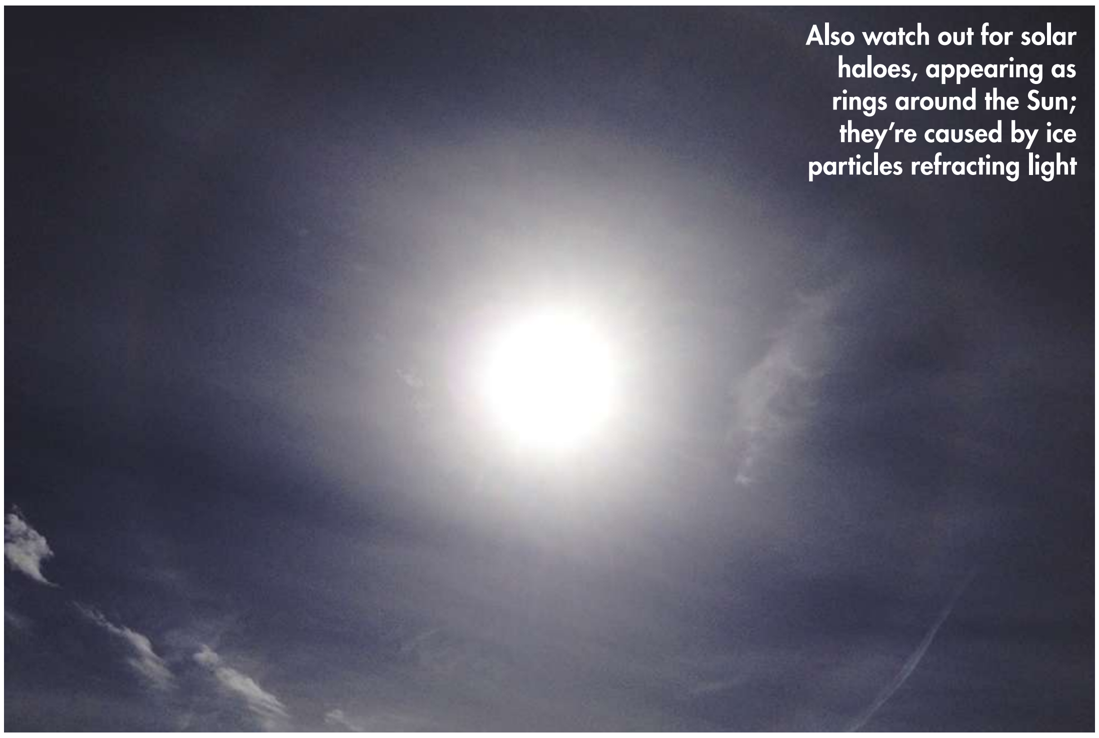
STEP 2

If your phone has HDR capability, turn it on. Many HDR-capable phones give the option to save the original shot and the phone-processed HDR image. If so, it's a good idea to make use of this.



STEP 3

Final tweaking in a third-party app can really help to make the final result that bit more dramatic. Be careful here not to overdo it though, as it is very easy to push things too far.



Also watch out for solar haloes, appearing as rings around the Sun; they're caused by ice particles refracting light

ATMOSPHERIC PHENOMENA

Clouds are normally a nuisance, but there is one type that can be seen in the summer months that are most welcome

WHEN WE LOOK up at the sky from the surface of the Earth, we're looking up through the atmosphere of our planet. The light from the Sun can create all manner of interesting effects within this atmosphere and these are often bright enough to photograph with a smartphone. Auto exposure settings can cause issues with bright phenomena but an HDR setting, if available, is normally able to keep this in check. Alternatively, use an app that lets you use your camera in manual mode.

Effects caused by the Sun, such as circumzenithal arcs, solar haloes and sundogs, make for great photos. Those caused by moonlight are good too, but are harder to capture because of the lower light levels when they appear. Of course, different phone cameras have different levels of capability for night-time photography, so what doesn't work for one make or model may well work for another. The bottom line here is to have a go.

If you think that this is all sounding a bit meteorological then we can bridge the gap between meteorology and astronomy by trying to capture noctilucent clouds which, if they appear at all, will do so typically from late May through to early August. These 'night-shining' clouds are seven times higher than regular clouds. At that height, they can still catch the Sun when it's below the horizon for us on the ground. This makes them appear to shine at night.

A bright noctilucent cloud display should register with some phones. Long exposure or stacked exposure apps can really help here. They can't be seen during the day, but aiming to catch it as the sky is starting to dim in the evening, or brighten in the morning, can bring enough light for the camera's auto functions to kick in. Be aware that this then becomes a balancing act: if the sky is too bright, the noctilucent clouds will fade out of view.

NEXT STEPS...

If you're able to hold your phone steady, consider taking a number of shots of the scene and stacking them together using a freeware, computer based application such as StarStaX (www.markus-enzweiler.de/StarStaX/StarStaX.html). This will average the results, so reducing image noise.

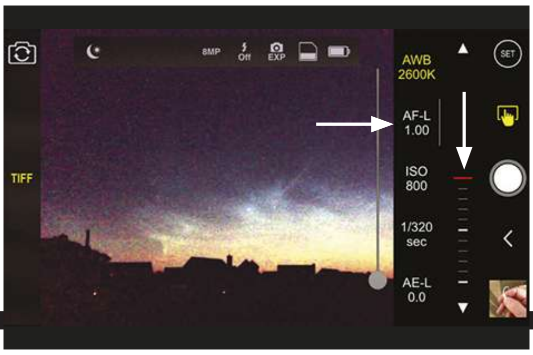
HELPFUL APPS

Night Modes (iOS; £1.49)
ProCam (iOS; £3.99)
Long Exposure Camera 2 (Android; free)
Night Camera (Android; free) ▸

How to photograph night shining clouds while the Sun is down

STEP 1

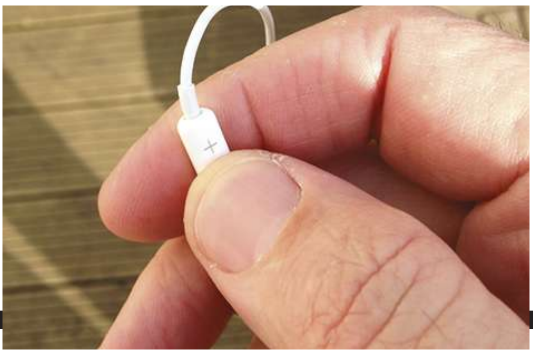
Trying to catch atmospheric effects such as haloes or arcs can prove tricky for your camera's auto focus. Either include a distant horizon or, if your phone's camera has focus control, use an app to set focus to infinity.



AWB
2600K
AF-L
1.00
ISO
800
1/320
sec
AE-L
0.0

STEP 2

If there's a bright display of noctilucent clouds underway, use an app that gives you manual control over your phone settings. Set the exposure between one and 10 seconds and ISO to 800. Again, focus should be at infinity.



STEP 3

Place your phone against a solid structure or use a tripod adaptor. Some phone camera shutters can be activated by the volume controls on certain headphones. Take a few shots to see what comes out.

BRIGHT PLANETS

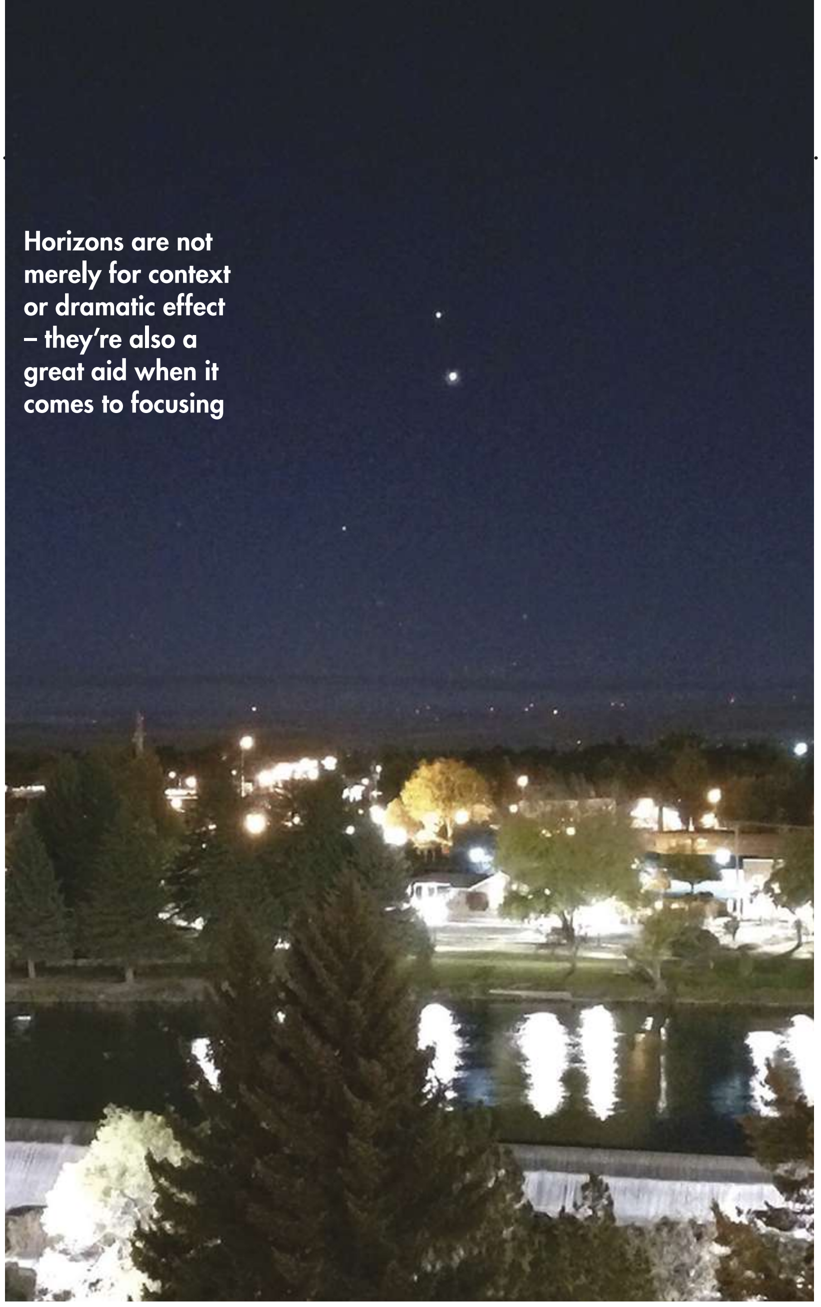
Mercury, Venus, Mars, Jupiter and Saturn are all viable targets for your phone

THE PLANETS CAN look amazingly bright to the naked eye, especially Venus. At present Venus is close to the Sun but will be returning to the evening sky at the end of 2016, and it will remain there in early 2017.

The most dramatic views of Venus occur when seen against a darker sky. However, focusing on what a camera phone will see as a bright dot can prove troublesome. One trick is to catch Venus above a lit horizon. As long as this horizon is far enough away, the phone's auto focus should lock onto the horizon, allowing you to grab a shot of Venus in context. Alternatively, some phones offer a 'focus lock' facility where you can point at any distant horizon and lock focus on that. Consult your phone's documentation to see if this is possible.

Mars and Jupiter can also become bright enough for many camera phones. The brightness of Mars is mostly unimpressive, but around opposition it can brighten considerably, even beating Jupiter to the position of second brightest planet. Mars reaches opposition on 22 May 2016, a great time to test whether your phone's camera can record its red-hued dot. The Red Planet will be at mag. –2.0 at this time, comparable to Jupiter. Again, use the trick of placing it above a distant lit horizon to achieve focus. There's another interesting opportunity with Mars at present because it lies close to Saturn in the sky. So as well as trying to catch a view of Mars, see if your phone can also record the much dimmer mag. +0.4, Saturn too.

Mercury is another contender for phone cameras. However, it can be a tricky spot because it normally appears against a twilight sky. This makes obtaining focus easier because you can use the distant silhouetted horizon, but timing is everything here – you need to let the sky darken sufficiently for Mercury to register in its own right.


Horizons are not merely for context or dramatic effect – they're also a great aid when it comes to focusing

NEXT STEPS...

If you want to record the planets as more than just dots, point your phone's camera down the pre-focused eyepiece of a telescope. Known as afocal imaging, this takes a bit of practice and a steady hand!

HELPFUL APPS

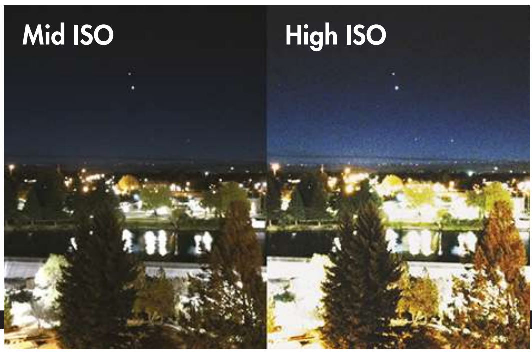
Night Cam (iOS; £1.49)
645 Pro (iOS; £2.99)
Camera FV-5 (Android; £2.49)
Open Camera (Android; free)

Pay attention to ISO and camera shake for clean planetary images

ALL PICTURES: PETE LAWRENCE

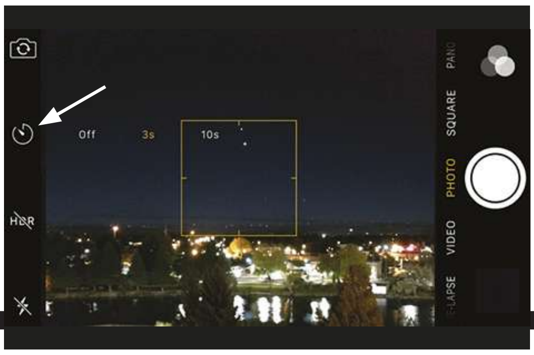
STEP 1

It really helps to have a distant horizon with recognisable lit regions in the shot for your camera phone to use as a focus target. If the horizon is interesting, include more of it to give some context to the shot.



STEP 2

Bright planets may register using your phone camera's auto functions. If not, use a control app setting the focus at infinity, mid to high ISO and exposure of one second. Lower the ISO if the result is noisy.



STEP 3

It's important to avoid camera shake so support the phone against a solid structure. If your make and model supports it, use the volume control on a pair of connected headphones to trigger the shutter.

CONSTELLATIONS

Push the limits of smartphone astro imaging with the familiar patterns of the night sky

STARS CAN POSE a more challenging target for many camera phones because they simply lack the brightness to register properly. The advice is, as ever, to give it a go and see what you get. Focus is a big issue here because, where the inclusion of a bright or silhouetted horizon may work with the planets, it'll simply drown out delicate stars. An app that lets you take control of the camera, including focusing, is the way forward as long as your phone's camera supports focus control. If it does, there are several apps that present a slider to change the focus distance. If you're not sure where the best focus is, one way to achieve this is to practice in daylight on a distant object.

Once you've determined exactly how to set the camera's focus position to infinity, you'll need to push the camera's sensitivity to the max. This is where many cameras will run out of steam, only permitting low values for ISO and exposure. However, don't be defeated by this. Holding the camera still for the duration of even a one-second exposure is critical. If you move during the shot, the delicate starlight you're trying to capture will be moved across the camera's chip and the result won't be very good. Inexpensive tripod mountings for smartphones can work wonders.

Results from star shots can be rather unimpressive and just look dark. However, loading the image into an editor and stretching it can often produce some quite nice surprises. As long as you don't expect to go down to really faint stars, many camera phones are able to produce some very recognisable renditions of the brighter constellations. Don't worry about the stars trailing as your exposures probably won't be long enough for this.

NEXT STEPS...

Photographing the stars directly with a phone camera really tests how capable it is under low light conditions. If you don't get much detail in the shots you take, then you may have reached your camera's limit and it may be time to consider an alternative device for capturing your photos such as a DSLR.

HELPFUL APPS

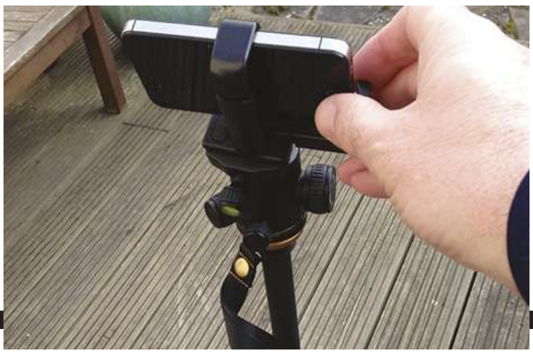
NightCap Pro (iOS; £1.49)
ProCam (iOS; £3.99)
Camera FV-5 (Android; £2.49)
StarTrail Photos Generator (Android; free)

Star trailing won't be an issue – the exposures you need to use are too brief for them to appear

Focus on steady shots if you want an image that may reveal stars

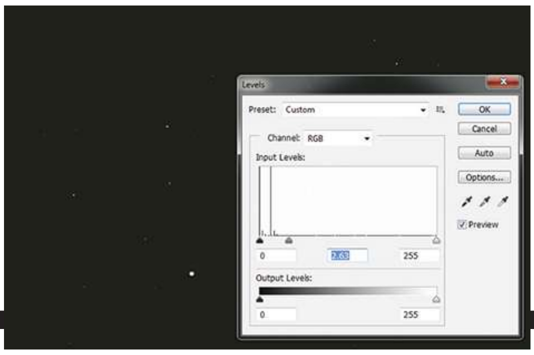
STEP 1

It's a good idea to start with the bright and more easily recognised patterns. Aim for Orion in the winter and Cygnus during the summer. Leo is a viable target in spring with Auriga and Taurus fitting the bill in autumn.



STEP 2

Make sure your phone is rigidly supported and use either a remote shutter lead or delay timer app to trigger the shutter. If possible, use a manual control app to set infinity focus, a high ISO and an exposure of one second or greater.



Levels
Preset: Custom
Channel: RGB
Input Levels: 0 2.63 255
Output Levels: 0 255
☑ Preview

STEP 3

Even though the end results may simply look black, use a photo editor to change the Levels setting by moving the mid-point slider towards the white point. This may reveal the brighter starts visible during the shot.

The seasons of Mars

Not only does the Red Planet have seasons just like ours, they're also easy to see, writes **Paul Abel**

The changing of the seasons here on Earth can be quite spectacular. In many regions the whole landscape is transformed by the onset of spring: as the cold winter snows retreat and the days become longer, trees come into blossom and hibernating animals awaken. The people of ancient civilisations were particularly keen observers of these cycles, since their existence depended upon knowing when to plant seeds and harvest crops. It is no wonder that they constructed huge monuments to mark important dates like the spring equinox.

The well-defined seasons of winter, spring summer and autumn are the result of the Earth's 23.5° axial tilt. If the northern hemisphere is tilted towards the Sun it experiences summer, while the southern hemisphere experiences winter. Over the course of a year, both hemispheres experience all of the seasons, although because Earth's orbit is slightly elliptical they are not of equal length – summer in the northern hemisphere is longer than it is in the south.

Seasonal similarity

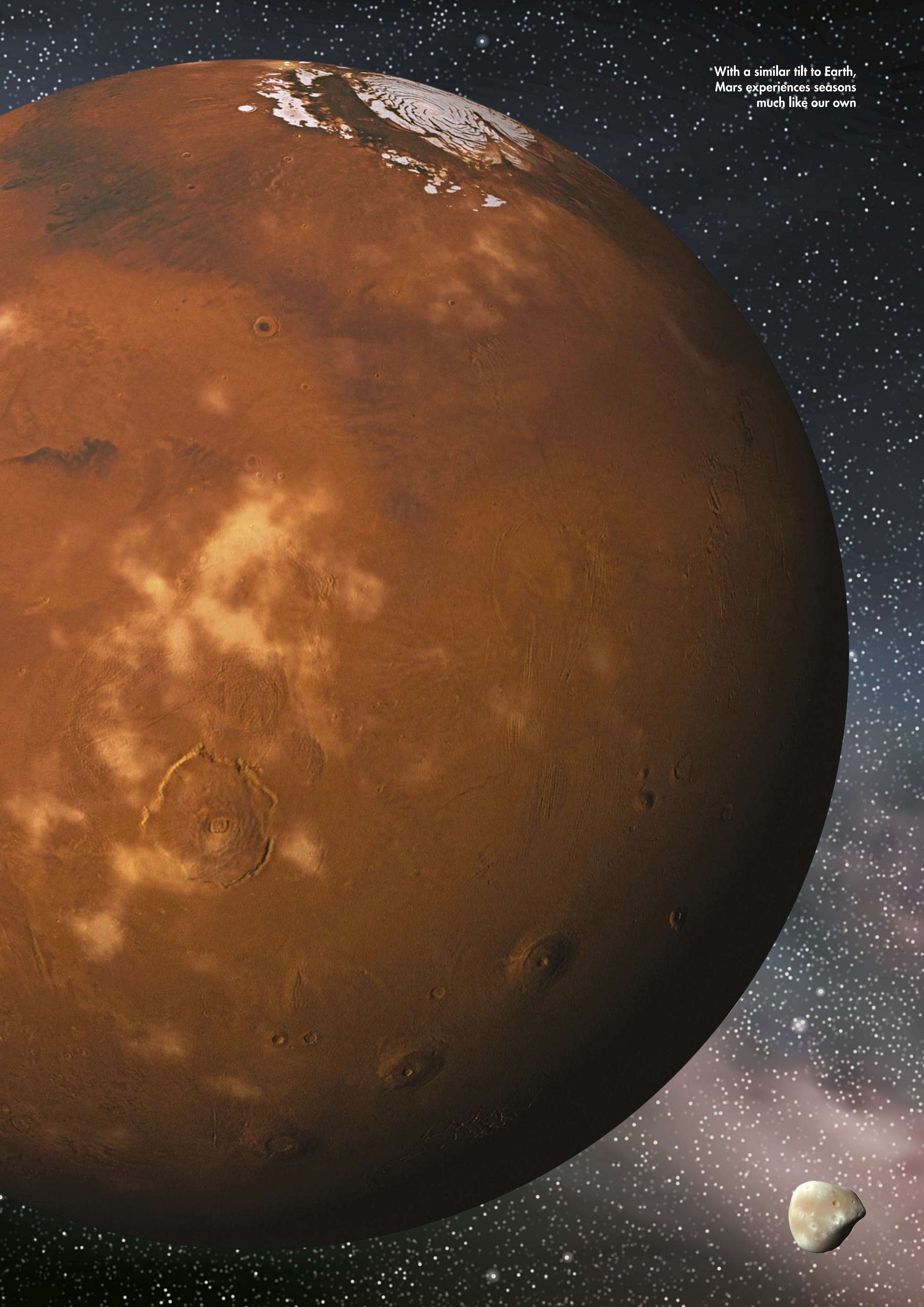
Earth is not alone in having an axial tilt – all of the planets do, from Mercury's fractional 0.03° to Uranus's massive 82.2°. But Mars's tilt is the closest to Earth's at 25.2° and as such it experiences similar seasons – although being farther from the Sun means they last for longer.

Consequently, Mars is a very dynamic world, where the changing of the seasons can produce dramatic, planet-wide changes that are visible in small telescopes. Mars comes to opposition ▸

ABOUT THE WRITER

Dr Paul Abel is an astronomer at the University of Leicester. Listen to him on our Virtual Planetarium.

ISTOCK X 2, NASA/JPL-CALTECH/UNIVERSITY OF ARIZONA X 2

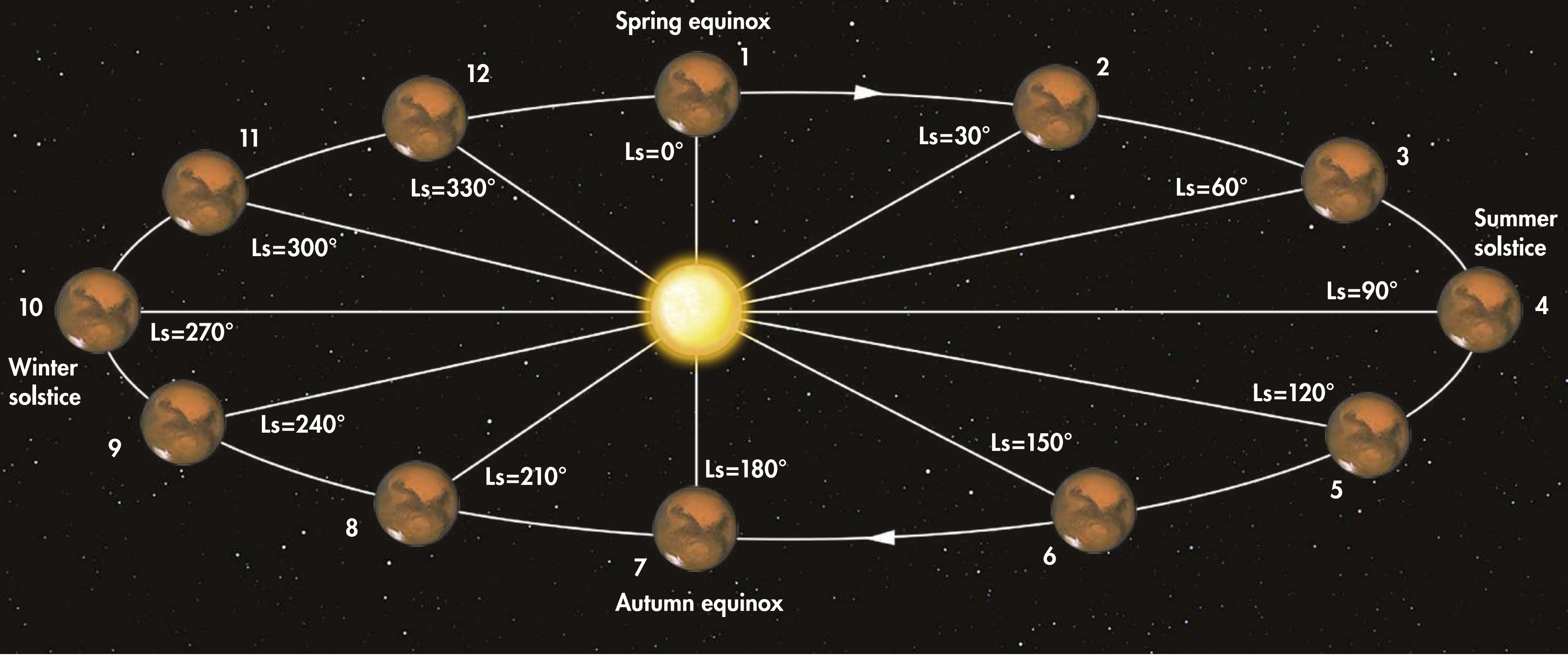


With a similar tilt to Earth, Mars experiences seasons much like our own

A MARTIAN CALENDAR

The 12 months of Mars, and some events to expect in them

MARTIAN MONTH	MARTIAN SOLAR LONGITUDE (LS)	EVENT
1	0-30°	Spring equinox (northern hemisphere) at Ls=0°
2	30-60°	Autumn in the south
3	60-90°	Northern ice cap shrinking; white cloud activity
4	90-120°	Summer solstice (northern hemisphere) at Ls=90°
5	120-150°	White cloud activity still possible (March, April)
6	150-180°	Autumn equinox (northern hemisphere) at Ls=180° (June)
7	180-210°	Start of dust storm season (July, early August)
8	210-240°	Spring in the south (August, early September)
9	240-270°	Winter solstice (northern hemisphere) at Ls=270° (October, November)
10	270-300°	Southern hemisphere now tilted towards us (November, December)
11	300-330°	Winter for the northern hemisphere; Mars is now very small
12	330-360°	End of dust storm season



▸ on 22 May, and although it will be low down for observers in the UK observers it will be large and bright, and over the next few months it will undergo some fascinating changes.

These changes can have a lasting effect. Mars has been closely scrutinised by Earthbound astronomers from the middle of the 19th century onwards, and despite our early ideas about Martian seasonal changes being due to vegetation were wrong, the fundamental idea that its seasons have a lasting effect on its features is correct. All you need to do to see just how much Mars's surface has changed is compare a map of Mars from the 1950s to a current one.

In order to keep track of seasonal changes, we need to devise a calendar for Mars. Astronomers use a quantity called Martian solar longitude, or 'Ls', which is measured in degrees. Examine the diagram of Mars's orbit above, and you see that the orbit has been divided into 12 months represented by 30° segments. For Mars's northern hemisphere, 0-90° is spring time, 90-180° is summer, 180-270° is autumn and 270-360° is winter. Just like Earth, the Martian hemispheres experience opposite seasons, so if it is spring in the northern hemisphere it will be autumn in the south.

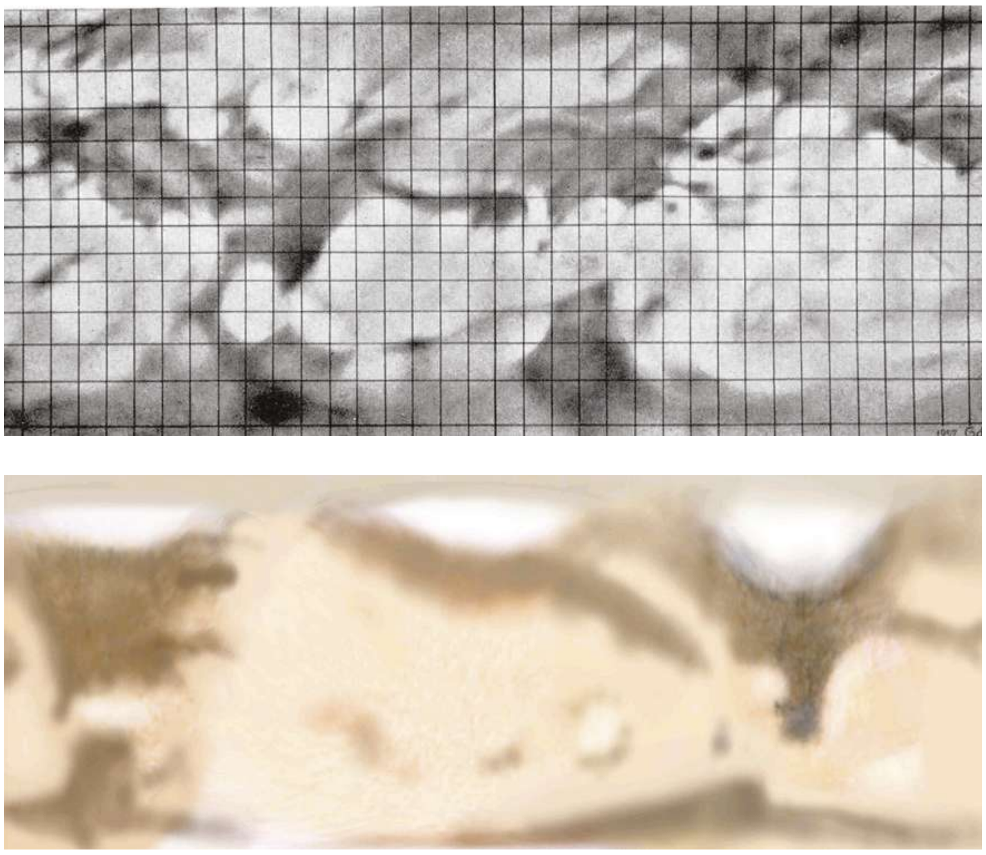
▲ When the north polar cap shrinks a dark band can appear around it

ILLUSTRATION BY PAUL WOOTTON, DAMIAN PEACH, PAUL ABEL, NASA/JPL-CALTECH/ MSSS, NASA/JPL, NASA/JAMES BELL (CORNELL UNIV.) MICHAEL WOLFF (SPACE SCIENCE INST.) AND THE HUBBLE HERITAGE TEAM (STSCI/AURA)

Month by month

By the end of May, Mars will be a reasonably large 18 arcseconds, and its northern hemisphere will be slightly tilted towards us. By the time of opposition, Martian solar longitude has a value of 157°, so it is will be early summer in the north. You can look up the value of Ls in the freeware program WinJupos (www.grischa-hahn.homepage.t-online.de).

The large northern polar ice cap will now have shrunk dramatically, appearing as a small white



▲ It's clear to see how Mars's surface has changed over time: the top image is a 1957 map produced by G de Mottoni, while below it is a more recent sketch by the author

patch in the far north. As the cap recedes, a dark band can usually be made out surrounding it. This is the Lowell band, which can sometimes be very prominent and appears a dark brown in colour. With a 6-inch or larger telescope you may also be able to see an equatorial cloud band, which can give the northern part of Syrtis Major a distinctly bluish cast.

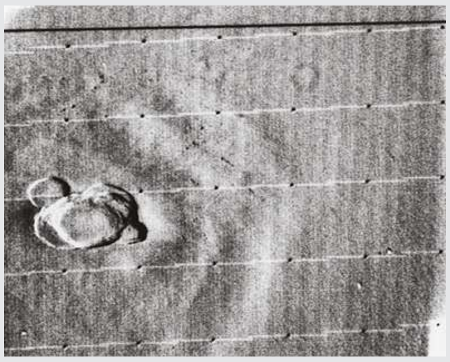
The melting of the north polar cap returns a lot of volatiles into the Martian atmosphere, and over the following months you should keep a look out for bright white clouds and fog patches. There are a number of well known places where they form: the Hellas, Argyre and Chryse basins for example. Sometimes they form around the vast shield volcano Olympus Mons or the other volcanoes in the Tharsis Plateau. Clouds and fogs sometimes encroach into the darker albedo features; you can enhance their contrast using a blue filter such as a Wratten number 80 (W80). If they form on the sunward limb, you can watch them dissipate as Mars rotates and the late morning Sun disperses them.

By the end of July, solar longitude on Mars will be 195°. Summer will have now given way to autumn and it will be slowly getting colder in the north. However, spring will have arrived in the south and the southern ice cap will now start retreating, and by the start of August the dust storm season will be underway. This is the time to keep a look out for storms which usually start off as small orange clouds. They may remain small or they can continue to develop until they have encompassed the entire globe, hiding all but the most prominent features.

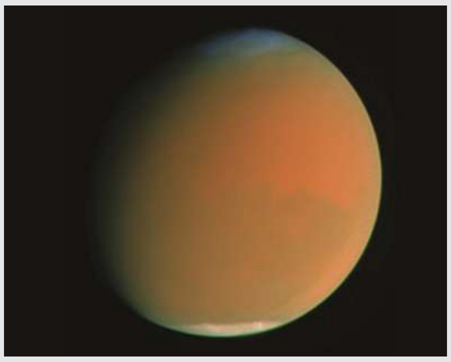
By October, the southern hemisphere will be tilted towards us. It will be spring in the south, and if you have access to an 8-inch telescope you should be able to follow the shrinking of the south polar cap over the next couple of months. By the end of November, Martian solar longitude will be 271°, marking summer solstice for the southern hemisphere. The Martian disc will now be small, but imagers with large telescopes should still be able to pick out any dust storms. Ⓢ

DUST IN **THE WIND**

Tiny dust storms can develop into planet-wide events



▲ Dust masks the outer ring of Olympus Mons in this Mariner 9 shot from 1971



▲ The 2001 global storm seen by Hubble blotted out most surface features

Although the Martian atmosphere is not very substantial, it can still produce winds that can develop into dust storms. The storms begin as small orange clouds, and can grow quite rapidly. There are three categories:

1. Local: Small yellow-orange clouds usually less than 2,000km in size, but can encompass whole regions (such as the Hellas basin).

2. Regional: These are much larger and may affect a whole hemisphere.

3. Global: These cover the entire planet, and may hide the surface features for many months at a time.

In 2001, a dust storm was observed in the Hellas basin and developed into a global event shortly after. Another famous global dust storm occurred in 1971, obscuring the entire planet just as the Mariner 9 spacecraft arrived.

Dust storm season usually starts at a Martian solar longitude of 180°, so for this apparition the season starts in early July and will continue for the rest of the year. Small yellow clouds show up well in a red Wratten 25 filter, while a green filter can help to enhance larger storms.

MARS'S SHIFTING **ICE CAPS**

The extent of Mars's frozen poles varies greatly with the seasons

The polar ice caps of Mars can be very striking and can be glimpsed in a 4-inch telescope when prominent. The caps wax and wane with the planet's seasons. At the time of opposition, it will be summer in the north, and so the northern ice cap will have shrunk to a small white patch, and it will probably be quite difficult to see.

As we move into September, Mars's southern hemisphere will start to tilt towards us. It will be spring in the south, and from the end of October onwards you should be able to watch the large south polar cap start to shrink. A blue Wratten 80 filter will help enhance the polar regions. By December, Mars will be quite small, and so you'll need at least an 8-inch telescope and a magnification of 250x or more to see the south polar cap.

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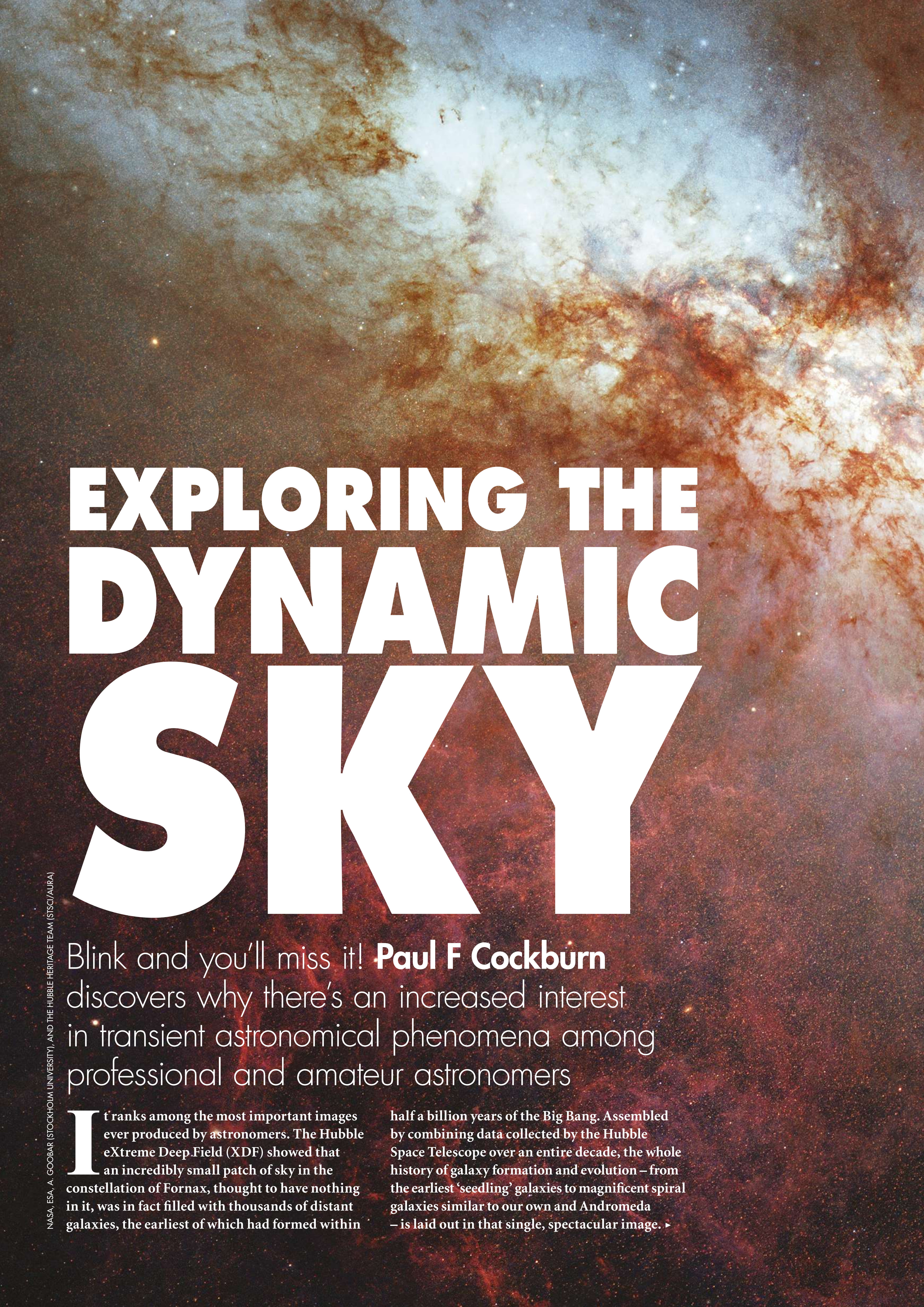
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EXPLORING THE DYNAMIC SKY

Blink and you'll miss it! **Paul F Cockburn** discovers why there's an increased interest in transient astronomical phenomena among professional and amateur astronomers

It ranks among the most important images ever produced by astronomers. The Hubble eXtreme Deep Field (XDF) showed that an incredibly small patch of sky in the constellation of Fornax, thought to have nothing in it, was in fact filled with thousands of distant galaxies, the earliest of which had formed within half a billion years of the Big Bang. Assembled by combining data collected by the Hubble Space Telescope over an entire decade, the whole history of galaxy formation and evolution – from the earliest 'seedling' galaxies to magnificent spiral galaxies similar to our own and Andromeda – is laid out in that single, spectacular image. ▸

Supernovae are the most widely known form of transient event; even the ancients recorded them, though they didn't know what they really were. This one is SN 2014J in M82

The Hubble eXtreme Deep Field, covering a patch of sky measuring 2.3x2 arcminutes, revealed thousand of galaxies we had never seen before

▸ Yet as Dame Jocelyn Bell Burnell, the woman who discovered the first pulsars while completing her PhD at the University of Cambridge in the 1960s, has pointed out on several occasions, there is a price to be paid for the clarity of the XDF. Given that the faintest galaxies in the image are one 10-billionth the brightness that the human eye can detect, Hubble had to stare at that small point in the night sky for quite a while; the combined exposure time for the final image is equivalent to some two million seconds – that's more than three weeks.

"It's superb stuff," she says. "That's what everyone's been chasing over the last few decades. How deep can we go? Can we see the earliest galaxies? What do they look like and what do the first stars look like?"

But there's also a snag about having these very long exposures, she says. "If something changes brightness or something moves, it gets blurred out," Bell Burnell explains. "You're not going to see a very rapid change in brightness lasting a second on the final photograph. Equally, if something moves, you lose a lot of the information."

Or, to put it another way, if you were to take a long-exposure photograph of a set of traffic lights, you'd know the lights were illuminated – but you wouldn't be able to tell the sequence in which they lit up. The study of transient astronomical events is something that has always interested Bell Burnell, and she's understandably gratified that the field has become much more mainstream in recent years.

Surprises in the sky

But what exactly is a transient astronomical event? "We're used to seeing the night sky and for it to be pretty constant in its appearance," says Dr Marek Kukula, Public Astronomer at the Royal Observatory Greenwich. "Of course the Sun and the Moon change their position against the background stars fairly rapidly on a timescale of days, weeks

> "If something changes brightness or moves, it gets blurred. You're not going to see a change in brightness last less than a second on a photo" – Dame Jocelyn Bell Burnell

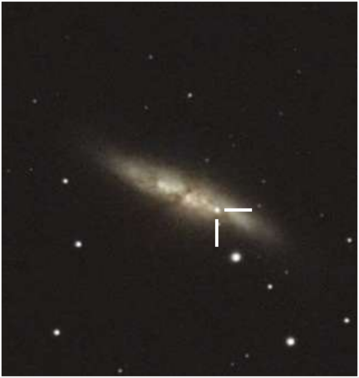
KEEP WATCHING THE SKIES

There are many transient events you can search for yourself with binoculars, a telescope or a computer

NASA/ESA/G. ILLINGWORTH/D. MAGEE AND P. OESCH/UNIVERSITY OF CALIFORNIA/SANTA CRUZ/R. BOUWENS/LEIDEN UNIVERSITY AND THE HUDF09 TEAM, © GARY DOAK/ALAMY STOCK PHOTO, © GALAXY PICTURE LIBRARY/ALAMY STOCK PHOTO, ISTOCK X 2, ROYAL OBSERVATORY GREENWICH, NASA/ESA/S. BECKWITH (STSCI) AND THE HUDF TEAM, JON LOMBERG/SCIENCE PHOTO LIBRARY

SUPERNOVAE

What you need:



"These things are so bright; one supernova can outshine all the billions of stars in its galaxy," says Dr Marek Kukula. "There are all these great stories about supernova discoveries where people are going: 'Hang on, that doesn't look right!', comparing it to their charts, and going: 'That wasn't there before!'"

Report a new supernova: www.cbat.eps.harvard.edu/HowToReportDiscovery.html

COMETS

What you need:

Professional astronomers don't officially classify comets as transient phenomena, but arguably there's no way anyone can predict with 100 per cent accuracy the scale and luminosity of even the most reliably plotted comet on each of its circuits round the Sun. And, of course, a one-off comet always remains a possibility.

BAA comet section: www.britastro.org/section_front/10

> “Amateurs live on pretty much every continent – there is somebody looking at the sky pretty much every hour of the day” – Dr Marek Kukula

and months. The planets move against background stars, and you can see that motion on a timescale of days, weeks, months and years. So, to some extent, those are transient phenomena.

“But really, professional astronomers are talking about a class of phenomena which can happen on timescales of seconds, minutes, hours and days. Sometimes weeks or months, but things that are either regular events or more often one-off events. Things that, when they happen, you need to grab the opportunity to study.”

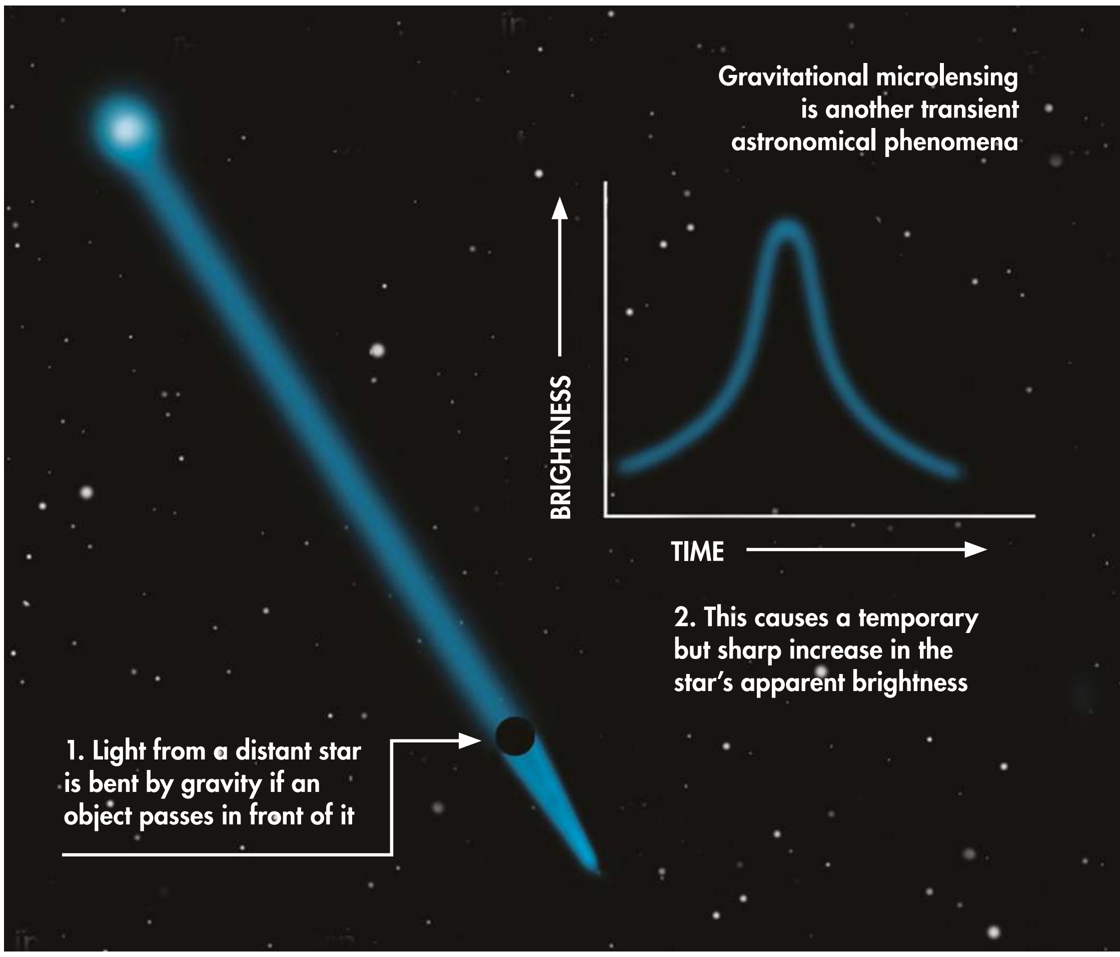
Some of these events been noted for centuries; for example, stars which were not visible to the naked eye which then become much brighter very suddenly – perhaps in a timescale of hours – and then shone for a few days, weeks, or months before fading away again. We now know these to be exploding stars, or supernovae – arguably among the most extreme explosions in the Universe.

The irks of unpredictability

Flaring can also be caused when a star or planet-sized body passes in front of a much more distant star and, for a brief time, its gravity lenses the light of the background object, causing it to brighten. “We have absolutely no means of predicting when and where they’re going to occur in the sky,” says Kukula, “and when they do occur we know that we’re never going to see that particular object do the same thing again.”

This unpredictability means there are two things you need in place in order to study the dynamic sky. “You need to be scanning a lot of the sky a lot of the time, and then you also need the capability – either with the same telescope or with a complementary telescope – to swing into action and home on these things and study them for that brief period – of perhaps a few hours or days – when its active,” he says.

“This is where the amateur community can really help,” Kukula adds. “There are far more amateur telescopes out there than there are professional ones. And, of course, amateurs live on pretty much every continent – there is somebody ▸



Gravitational microlensing is another transient astronomical phenomena

1. Light from a distant star is bent by gravity if an object passes in front of it

2. This causes a temporary but sharp increase in the star’s apparent brightness

METEORS AND METEORITES

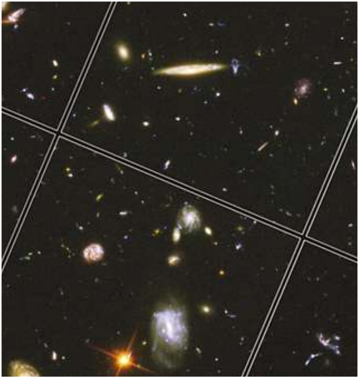
What you need:

As the explosive Chelyabinsk fireball proved in 2013, meteors can be equally unpredictable! Despite increased observations, we still can’t detect every near-Earth object, so useful information can be gleaned from a meteor’s direction and angle of flight – even colour, which tells us something about the material that’s burning up.

SPA meteor section: www.popastro.com/meteor/index.php

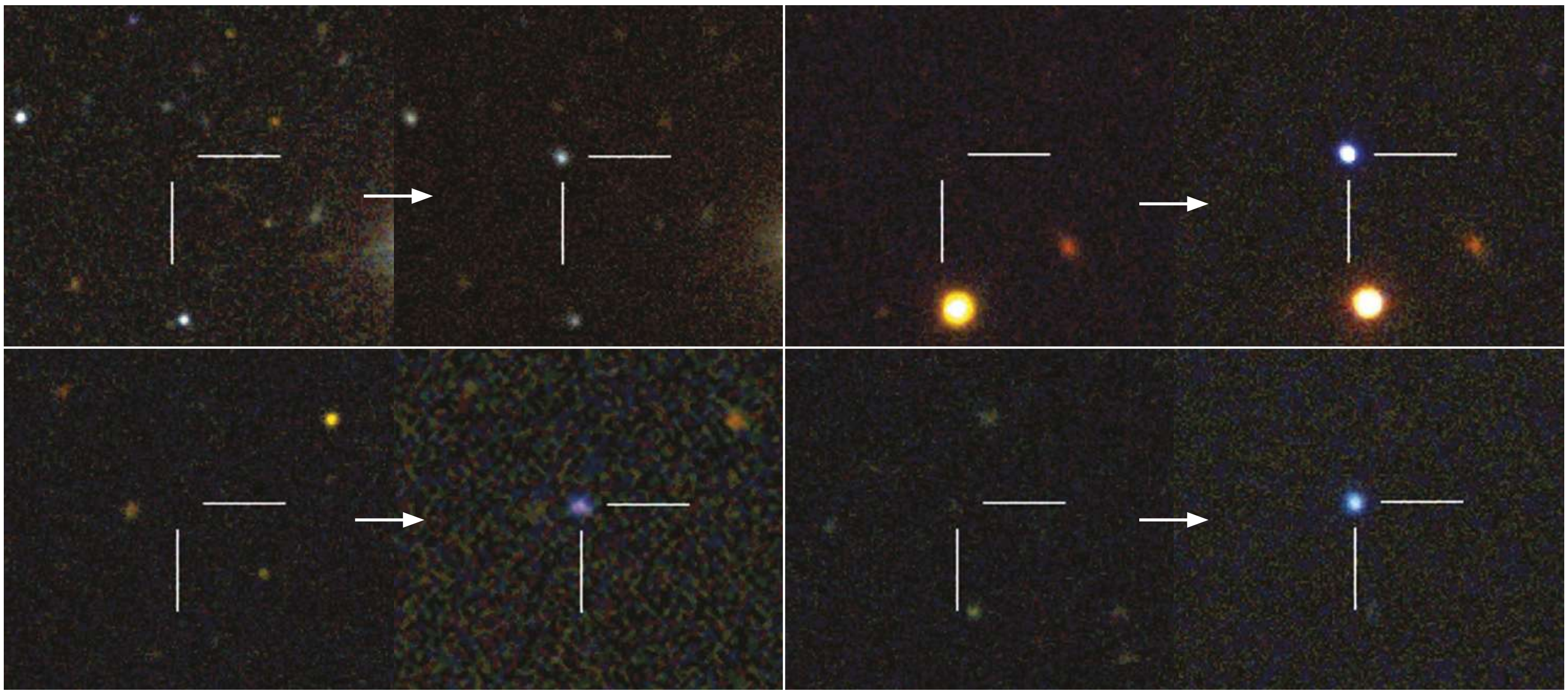
CITIZEN SCIENCE

What you need:



You don’t even need a telescope! Citizen science projects such as Galaxy Zoo – which utilise the huge amounts of visual data from major observation platforms such as Hubble – still rely on our innate pattern recognition abilities to pick up those anomalies that even the best current computer algorithms can miss.

Citizen science research: www.zooniverse.org/projects



▸ looking at the sky pretty much every hour of the day, somewhere around the world, so the chance of picking up something unusual flaring up is pretty good. Amateur astronomers definitely still have something to bring to the table because they're not computers, and this isn't data that's going to be looked at later; this is somebody looking through their telescope now.

"With the internet, there's a network where people can inform other people, and then not only other amateurs but also professionals can turn their telescopes and start to study. There's this nice synergy of amateur and professional astronomers facilitated by the internet, enabled by the fact that amateur astronomers now have pretty good kit and are really knowledgeable about what to look for."

▲ Four supernovae discovered by the Palomar Transient Factory; the images on the left show each before the explosion, the ones on the right after the fact

THE PALOMAR TRANSIENT FACTORY

The allure of extremes

But why are astronomers now so interested in these transient phenomena? Kukula says that from an astronomer's point of view, short-lived astronomical events tend to be very extreme in terms of the energy and forces involved. These are things like stellar explosions, gravitational microlensing and tidal disruption – when a star pulls an object apart, or material orbiting a black hole or neutron star gets to a certain critical point and disintegrates.

"The attraction of that for astrophysicists is to be able to observe nature in extremis – to observe some of the most powerful events in the cosmos," he says. "That tells you something about how the laws of nature, the laws of physics, work."

ABOUT THE WRITER

Paul F Cockburn is a freelance journalist who has been writing about science and technology – past, present and future – since 1996. He is based in Edinburgh.

THE EXPERT

Edo Berger is a professor of astronomy at Harvard University who researches short-lived explosive and eruptive astrophysical phenomena

Why are you interested in transient astronomical phenomena?
My research interests when I started in graduate school revolved around trying to understand gamma-ray bursts about which very little was known at the time. The sense of exploring something new in the Universe that was very little understood appealed to me from day one. A lot of what we're trying to do is to actually discover new types of objects, and I find that intellectually stimulating.

What difference have technological advances made in recent decades?
People have known about supernovae for hundreds of years; they didn't really understand them, but they knew about them. We now have the ability to build telescopes and faster computers that can process data in real time, and that really allows us to make very rapid progress in understanding these sources.

We're also in an era of astronomy where we're not just using visible light. Radio, gamma ray and X-ray telescopes give us a much broader view of the Universe that goes beyond the capabilities of our human eyes. For example, if we find a supernova using a visible light telescope, we can then go and observe that object in radio waves, in X-rays and in gamma rays, and that gives us a much more complete picture of the nature of the explosion, the underlying physics, and what kind of object it was.

What are you excited about in the future of the field?
The LIGO gravitational wave detectors will open up a completely new view on finding transient sources and time-domain phenomena. I think that will be a complete revolution in the field; not only will we be able to see these sources through their production of gamma rays, X-rays, visible or radio waves, but we're now going to discover them through their gravitational waves.

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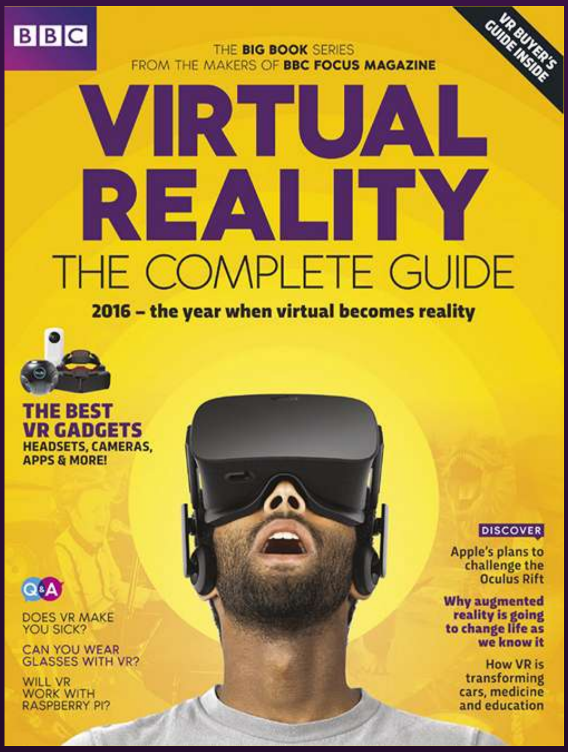
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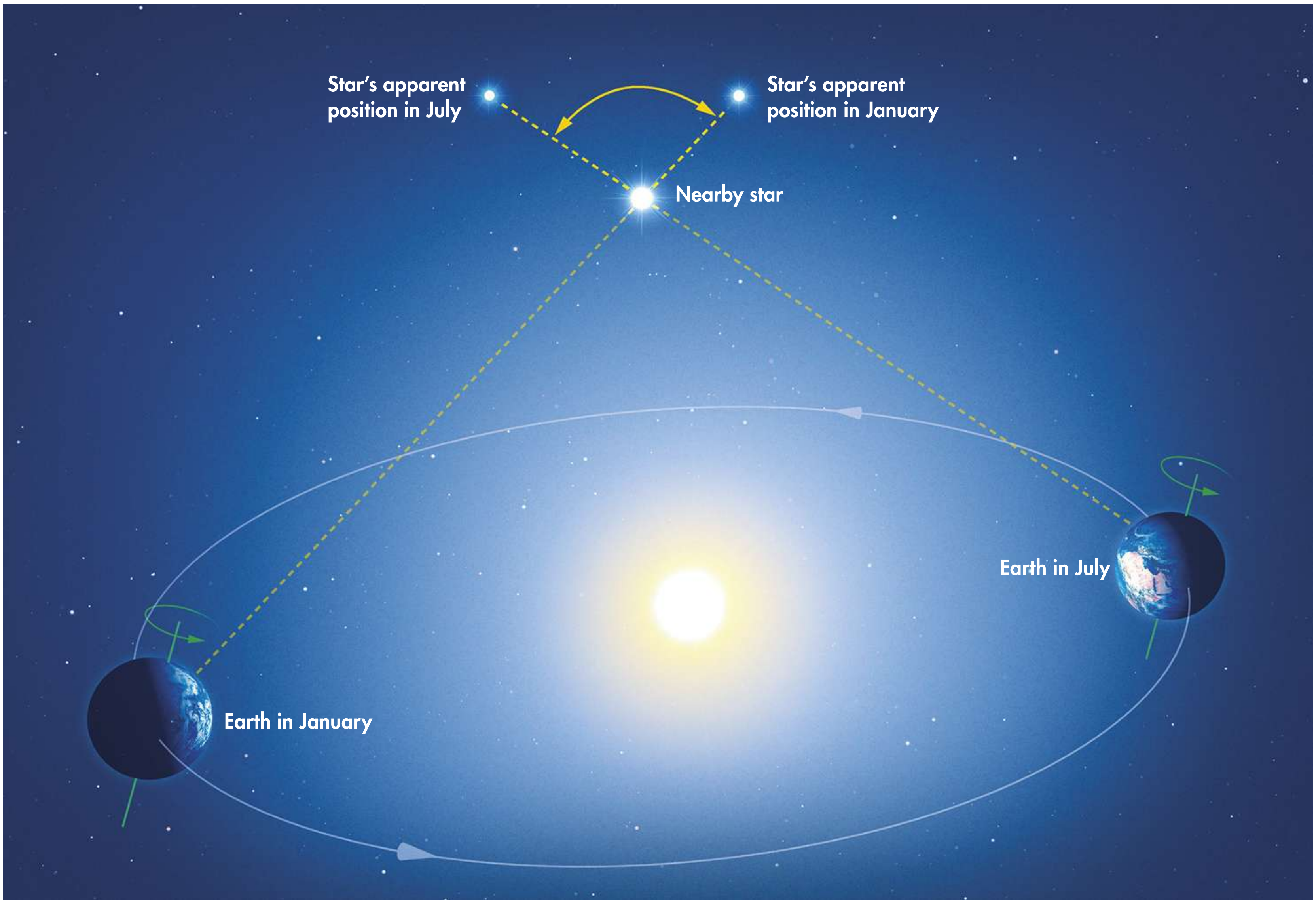
The Guide

Parallax and stellar distances

With **Brian Jones**

How a simple observational technique kickstarted our quest to map the sky


Star's apparent position in July
Star's apparent position in January
Nearby star
Earth in July
Earth in January

▲ **Trigonomic parallax involves looking for changes in a star's position relative to the background sky due to Earth moving in its orbit**

Parallax is defined as the apparent angular shift of a nearby object against a more distant background when viewed from two different locations. In astronomy, the principle of parallax is used to measure distances to the closer stars. The values obtained form the first 'rung' of the cosmic distance ladder, the product of a succession of techniques by which astronomers determine distances to increasingly remote celestial objects. Its purpose is to assess true luminosities of stars and other celestial objects, thus helping astronomers to build up a structural picture of our Galaxy and the Universe beyond.

The first attempt to establish the Earth-Sun distance, the most important rung on the cosmic distance ladder, was made by the ancient Greek astronomer Aristarchus. He reasoned that, at the time of first or last quarter Moon, the Moon must form a right-angled triangle with Earth and the Sun. In this scenario, the Moon would be at the 90° angle and the long edge of the triangle would link our planet and the Sun.

So, he theorised, if the angle at the corner occupied by Earth could be measured, basic trigonometry would allow him to deduce the angle at the Sun. He measured the angle Earth occupied as being 87°, meaning the angle occupied by the Sun was 3° (because the angles in a triangle add up to 180º). This led him to conclude that the Sun was around 20 times as far from Earth as the Moon, and therefore 20 times the size of our natural satellite. He wasn't right – he was off by a factor of 20 – but he clearly demonstrated that the Sun is much larger and farther away than the Moon.

New science, new ideas

Fast forward several centuries: Copernicus's heliocentric system and Kepler's laws of planetary motion had allowed astronomers to work out the

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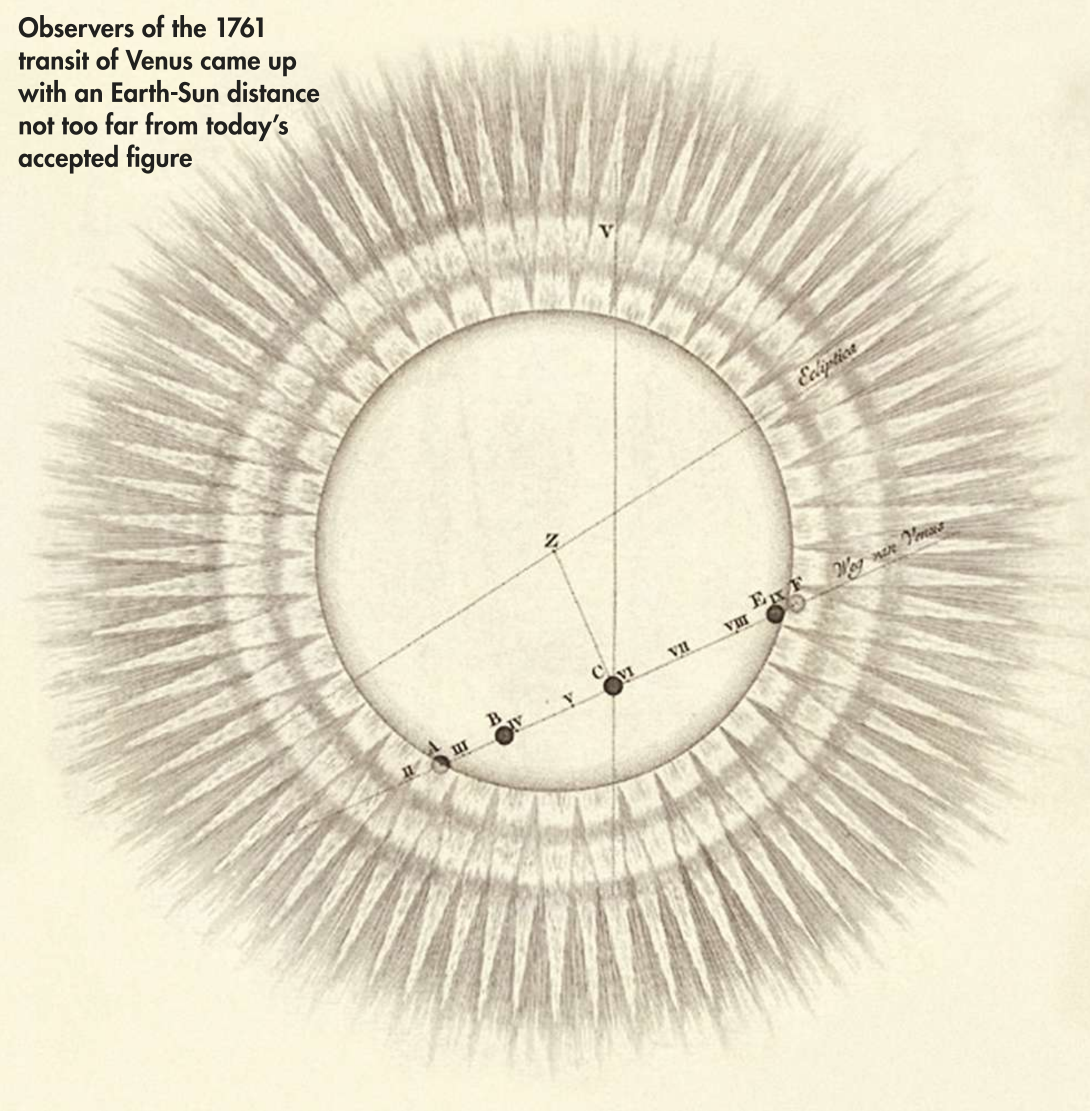


Observers of the 1761 transit of Venus came up with an Earth-Sun distance not too far from today's accepted figure

HOW FAR CAN WE MEASURE?

Measuring stellar distances by parallax involves observing a star from two different locations and assessing its shift against the background of more distant stars. Relatively nearby stars undergo shifts when observed from opposite points in the Earth's orbit and, by measuring this shift, and knowing the diameter of the Earth's orbit, the distance to the star can be calculated. But there are limits: for Earthbound observers, parallax is only effective for stars located within around 70 lightyears. Beyond this distance the angular shift of the star would be too small to be measured accurately.

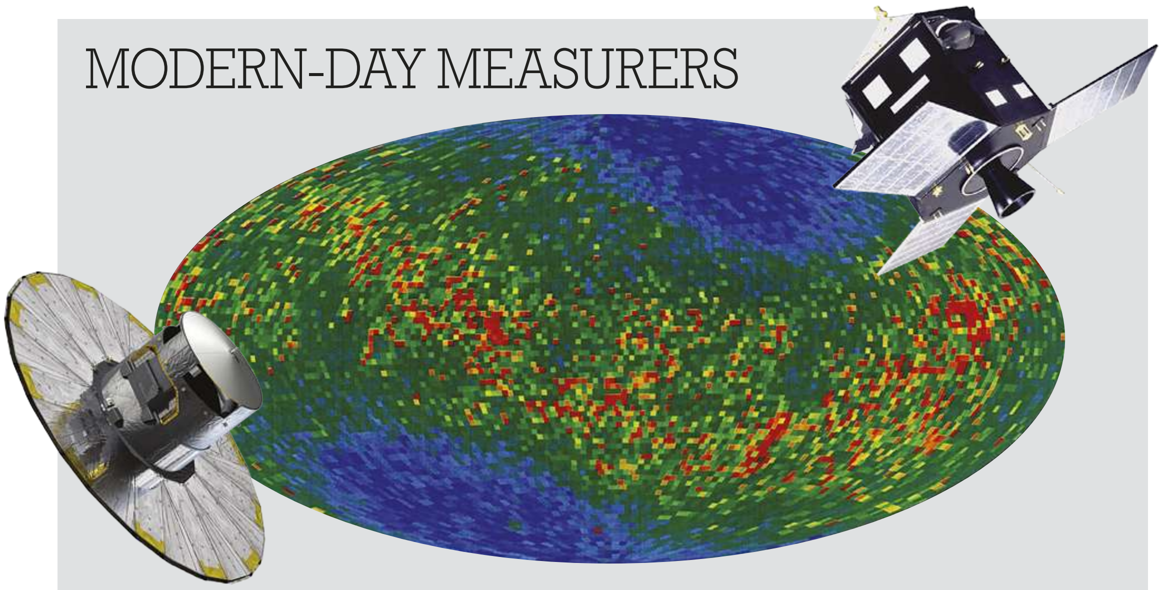
order and relative distances of the planets from the Sun, although they still could not calculate the true size and scale of the Solar System. However, knowing the actual distance of the Earth from the Sun would make this achievable. Observational errors had led to Aristarchus's results being flawed, and subsequent estimations were sketchy at best. Precise angular measurements were needed which, until the 18th century, were beyond the reach of available astronomical instruments.

In 1716, Edmond Halley suggested a way of calculating our distance from the Sun by observing transits of Venus from widely separated latitudes. Due to the effects of parallax, observers situated in Earth's northern and southern hemispheres would see Venus tracing out paths of different durations and lengths and at different latitudes on the solar disc. Observation and timing of the transit from both sites would allow astronomers to determine the distance to Venus, from which the Earth-Sun distance could be calculated. Halley died before the next transit occurred in 1761, but his suggestion was followed up, resulting in an estimate of 153 million km – not far from the currently accepted value of 149.6 million km.

The first star to have its distance measured by the parallax method was 61 Cygni. German astronomer Friedrich Wilhelm Bessel noticed that 61 Cygni had a comparatively large proper motion and he decided to try and determine its parallax. Bessel had access to good quality telescopes and equipment, allowing him to measure the tiny parallax shift of 61 Cygni, which he worked out to be at a distance of just over 10 lightyears. Comparison with the currently accepted value of 11.4 lightyears is testament to Bessel's skills as an observer, and his efforts finally gave astronomers an idea of the distribution of stars in the solar neighbourhood, and the immense distances involved.

Brian Jones has written 17 books on astronomy and space

MODERN-DAY MEASURERS



▲ Gaia (left) is continuing what Hipparcos started: mapping the Galaxy accurately

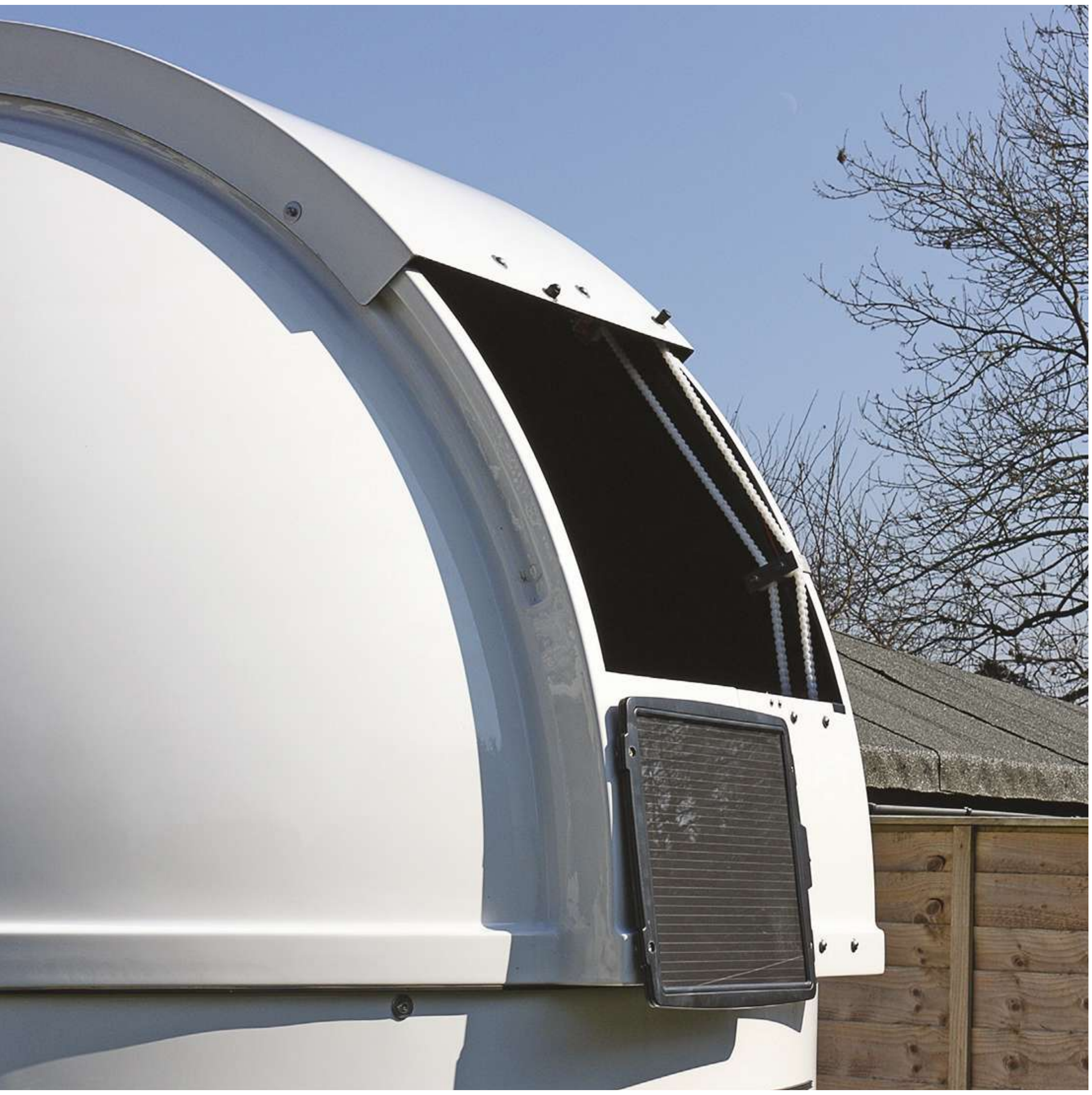
The mission to measure stellar parallaxes took on a new dimension in 1989 with the launch of ESA's Hipparcos satellite, the first mission dedicated to astrometry. It carried out precise measurements of the positions, distances, motions, brightness and colours of stars up until 1993, leading to the publication of three catalogues that upped the total of recorded stars to over 2.5 million. In 2013 ESA launched Hipparcos's successor, called Gaia. The satellite is in action right now, monitoring and measuring the positions, motions and properties of over a billion stars down to magnitude 20. Using its data, the mission team hope to create an accurate three-dimensional map of the Galaxy.

How to

Automate your observatory PART 2

With **Steve Richards**

This month: open your dome's aperture at the touch of a button



▲ Automating the dome's motion and aperture is the first step to an autonomous observatory

ALL PICTURES: STEVE RICHARDS

Last month we showed you how to automate the rotation of an observatory dome. This month we are going to take things a step further and automate the aperture opening.

All amateur domed observatories have a sliding lid that reveals a vertical rectangular aperture, giving access to the whole sky, including the zenith. This lid is normally operated manually, but automating the process has advantages – for example, you could add a detector that closes the aperture if it starts to rain. This kind of automation also opens the door to the exciting prospect of remote or even autonomous operation.

The curved profile of these apertures makes motorising them a little problematic, but the chain drive system described here is both elegant and secure. Because the dome must be free to rotate, it cannot be electrically connected to the rest of the observatory, so the aperture motor drive requires its own power supply. In the case of the Pulsar system we are using, this comprises a small, motorcycle-style 12V lead acid battery, along with a solar panel to keep the battery topped up and ready for action.

For the same reason, open and close commands from the main controller must be sent over a wireless link. In this project, a simple two-channel 433.92MHz radio frequency link connects to the main controller installed in Part 1. The latest version recently launched by Pulsar uses a bi-directional Bluetooth link.

Begin by removing the aperture lid to gain easy access for fitting the three guides and top return roller for the chain. It is important that these are placed approximately equidistant from one another, from the drive cog built into the motor housing at the bottom, and from the roller at the top. This ensures that the chain follows the contour of the dome aperture as closely as possible.

TOOLS AND MATERIALS

COMPONENTS
The Pulsar Shutter Drive system comprising an RF controlled motor drive housing, limit switches, 12V battery, solar panel, nylon chain, roller, chain guides and all fastenings

TOOLS
A variable speed drill with 2mm, 6mm and 8mm bits, a set of metric Allen keys, flathead and crosshead screwdriver, a set of metric spanners and a metal file.

SUNDRIES
Sandpaper, a marker pen, masking tape and a tape measure.

Connecting the chain

The position of the top roller is at the top edge of the aperture. Place the motor housing onto the flat vertical panel under the aperture opening ensuring that the top is 10mm lower than the bottom of the aperture opening. Mark the position of the

▲ A mounted solar panel will keep your motorcycle battery charged and ready for use

cog by placing a piece of masking tape aligned with it on the dome, in line with the left-hand side of the aperture as seen from inside the dome.

Place each of the three side-chain brackets over the dome edge in turn and position them equidistantly spaced. File the glass-fibre edge if necessary using a metal file and sandpaper until they are a neat, firm fit. Mark then drill a 2mm pilot hole clockwise through the fixing holes from the gelcoat side (the outside) and then drill 6mm holes. Do this with the drill running anticlockwise, so you grind a hole rather than drill it, to avoid damaging the gelcoat finish.

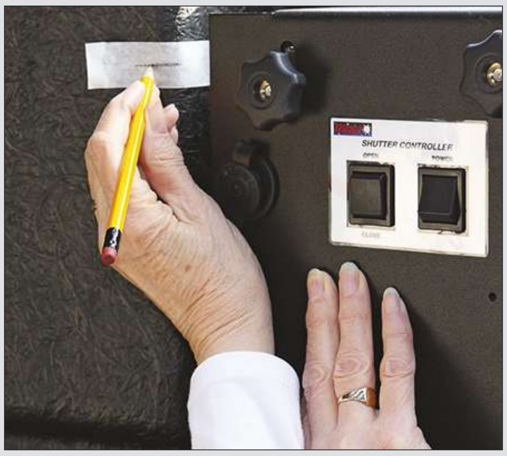
Bolt the three brackets in place using 6mm nuts and bolts and then loosely loop the nylon chain through each guide. This will help you to assess whether or not the guides are in perfect alignment with one another and if necessary, you can pack them with washers until the alignment is spot on.

Again, using the nylon chain as a guide, position the top roller in perfect alignment with the side chain brackets, mark the mounting holes and drill them in the same manner as for the chain brackets. Attach with bolts and check that the roller is carefully aligned and horizontal. Pack with washers to ensure correct alignment. Reposition the drive motor housing again, align the cog accurately with the nylon chain then mark and drill the mounting holes as before but using an 8mm drill bit. Attach it with 8mm nuts and bolts.

Mark, drill and attach the two limit switches and single limit switch actuator then mark, drill and attach the solar panel to the outside. Finally, connect the top limit switch, battery and solar panel to the motor housing and complete the chain around the drive cog. Ⓢ

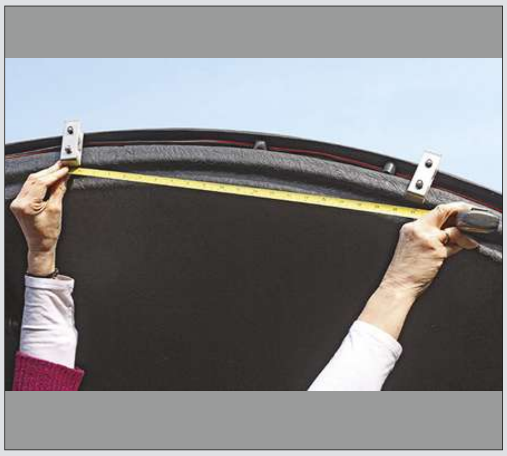
Steve Richards is a keen astro imager and astronomy equipment expert

STEP-BY-STEP GUIDE



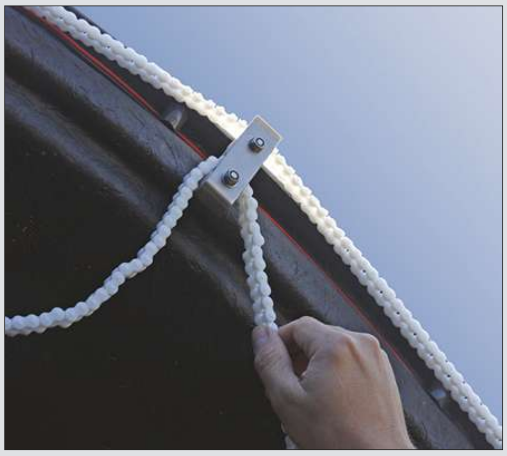
STEP 1

From inside the dome, place the motor housing onto the flat vertical panel under the aperture opening so that the top is 10mm lower than the aperture opening. Mark the approximate position of the drive cog in relation to the aperture wall with masking tape.



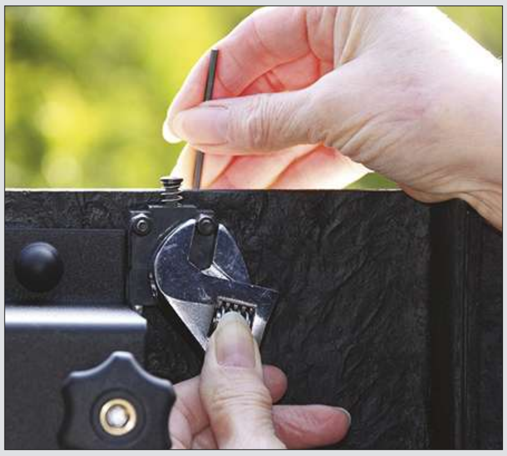
STEP 2

Remove the shutter and mark the position of the mounting holes for the top bracket and each of the three side-chain brackets, ensuring they are equidistant from one another and from the drive cog position. Drill 6mm holes and mount the brackets in position.



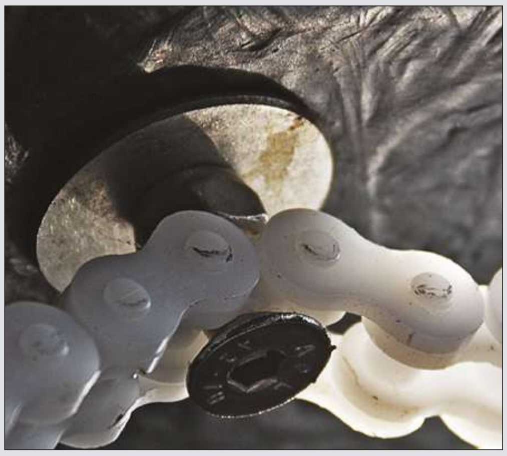
STEP 3

Lace the chain through the brackets, bringing the ends to the drive cog position. Ensure that all the brackets are aligned with one another. Reposition the motor housing again, aligning the cog accurately with the chain. Mark and drill 8mm holes and attach the housing.



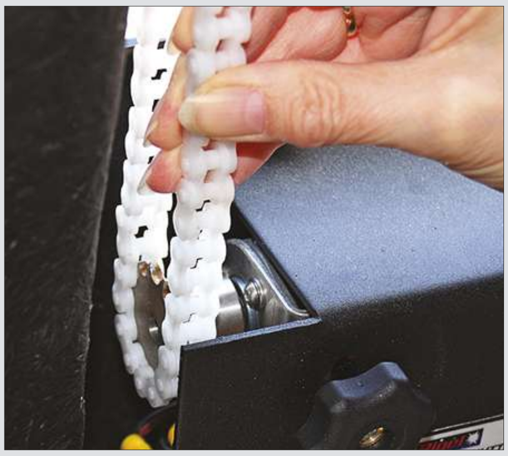
STEP 4

Mark, drill and attach the top and bottom limit switches to the dome. Mark, drill and attach the limit switch actuator to the lid and refit the lid. Run the switch cable from the top limit switch behind the chain brackets and down to the aperture bottom.



STEP 5

Close the shutter, allowing a 25mm overlap at the front of the dome, and position the chain against the shutter right next to the top bracket. Mark and drill a 6mm hole through the shutter and attach the chain to the shutter with a 6mm bolt.



STEP 6

Loop the chain around the drive cog and complete the chain with the final link. Mark and drill holes for the solar panel and attach it with the supplied bolts. Attach the lead from the top limit switch to the control board and connect the battery.

With **Matt Robinson**

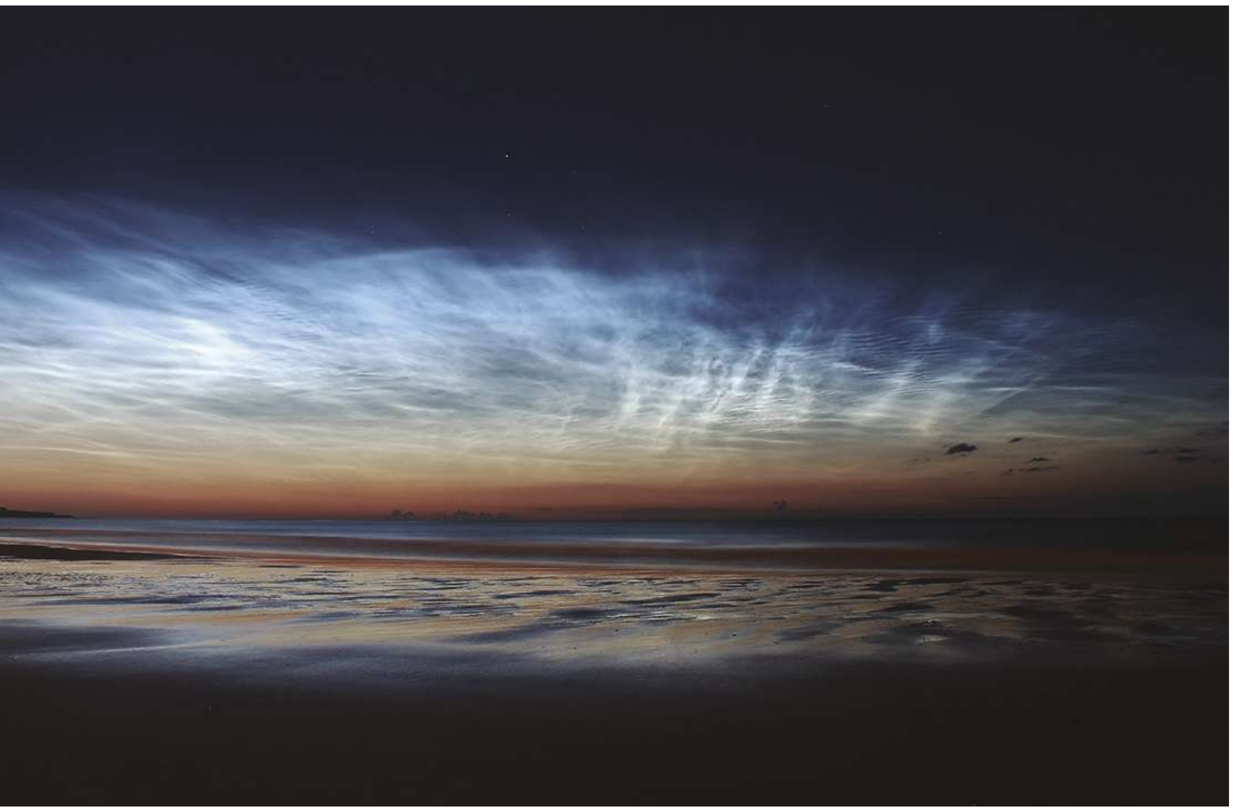
Image PROCESSING

INSIGHT ASTRONOMY PHOTOGRAPHER OF THE YEAR

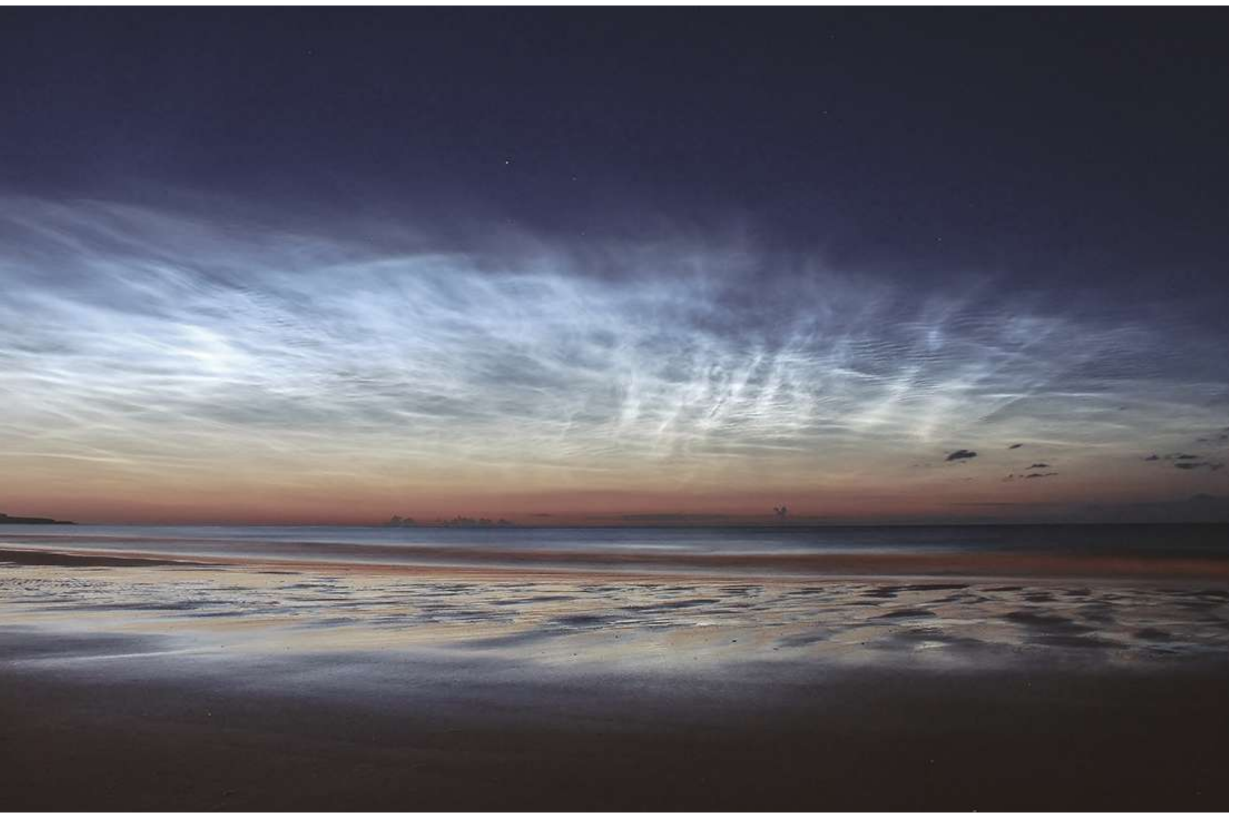
Expert advice from 2015's Skyscapes category runner up

Eerie and ethereal noctilucent clouds

Learn how to fix dark edges and get great colour in this summer favourite



▲ **Our starting image, a 20-second exposure at ISO 400; the vignetting is to be expected**



▲ **Your first task is to remove the darkened edges without overexposing the clouds**

Noctilucent clouds are incredibly beautiful, vibrant cloud structures that can be seen over the UK from late May until early August. They are comprised of ice crystals clustering together 80km above Earth's surface. When the Sun drops below the horizon in the evening they are illuminated from below, and when they appear you will know you're looking at them. Noctilucent clouds are much easier to see than the Northern Lights and are often just as impressive. They are best seen either 90-120 minutes after sunset low in the northwest, or 90-120 minutes before sunrise low in the northeast.

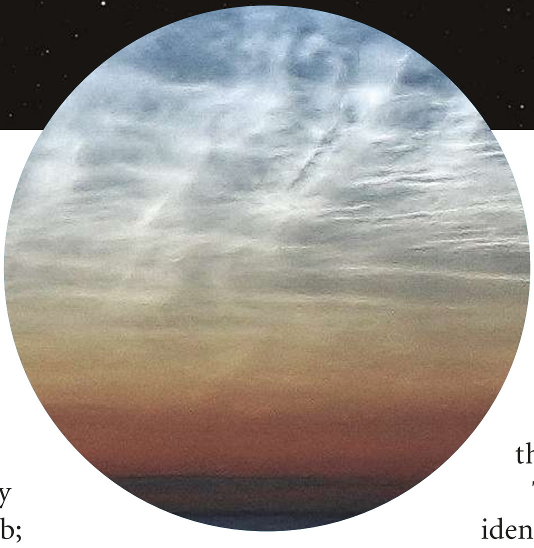
Because their illumination comes from the Sun rather than chemical interactions (as in auroral displays), noctilucent clouds are easier to observe and photograph from lower latitudes. However, because they appear at twilight it can be difficult to capture a balanced image of them. This can be due to the contrast between their brightness and the surrounding darkness of the night sky. Here we will show you a few simple steps towards processing your noctilucent cloud images to wow your friends with this summer.

Don't push the ISO

Our starting image was captured over Sunderland using a Canon EOS 1100D DSLR with the lens at 18mm and f/13. The ISO was at 400 and it was a 20-second exposure. It is important when taking pictures of noctilucent clouds to get the right balance with your camera settings. It is normal for your images to have some natural vignetting, so don't try to increase your ISO to fill the darker edges as this will leave you with grainy images that are difficult to process.

For processing, we're going to use Adobe Lightroom and assume your captures are in the RAW image format. Make a start by increasing the exposure and clarity to find the darkened boundaries of your image: in this case it is where the reflecting sand leaves the frame on the right . Do this by clicking the Develop tab; the 'basic' editing section will appear on the right of the screen. Move the toggle to the right on the Exposure and Clarity levels and monitor the change in your image. After this the clouds themselves will be overexposed, so you will need to decrease the highlights using the Highlights tab.

The second step is to identify the key colours in your image and breathe some life into them using the saturation tool. Noctilucent clouds are famous for their vibrant electric blue hues, which you should take advantage of. If you capture a display just before sunrise, you may also have the warm colours of the encroaching dawn appearing on the horizon, and this will provide nice composition for your image. Once you have identified the key colours, open the HSL tab in Lightroom. Locate the individual colour you wish to increase in the saturation section, click the tab and increase it modestly. Take care here: if you increase the saturation of your colours too much, your image will look more like a cartoon than the beautiful skyline you had in front of you.

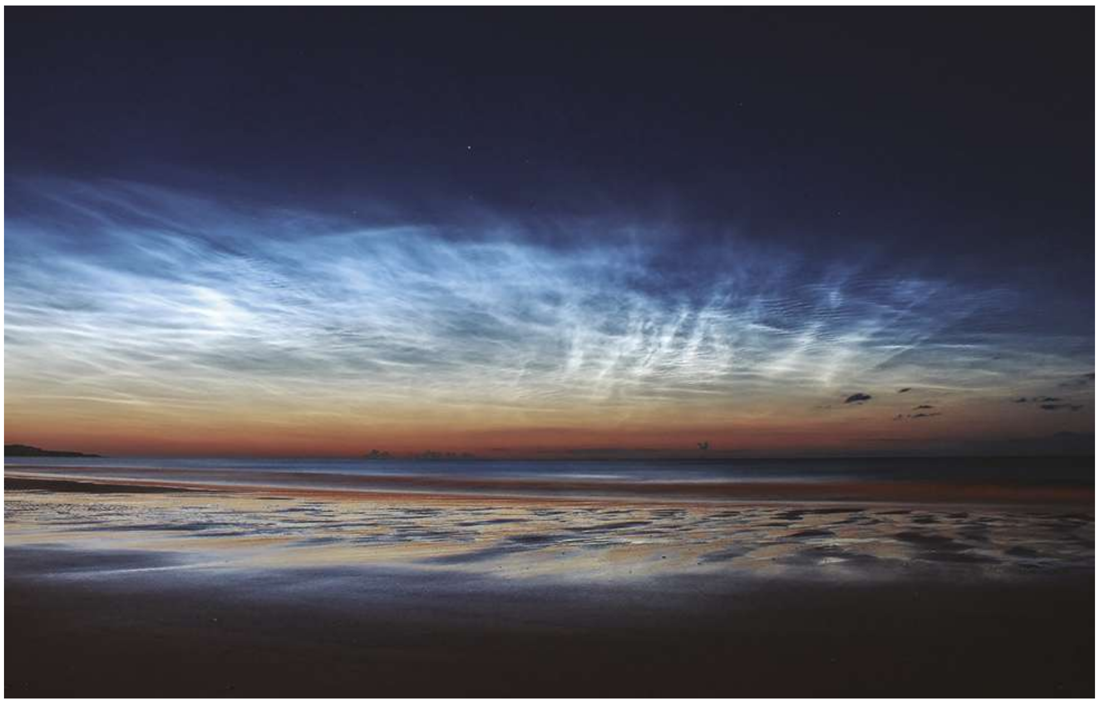


▲ Keep watch for your noctilucent clouds turning grainy, a result of the noise created while editing

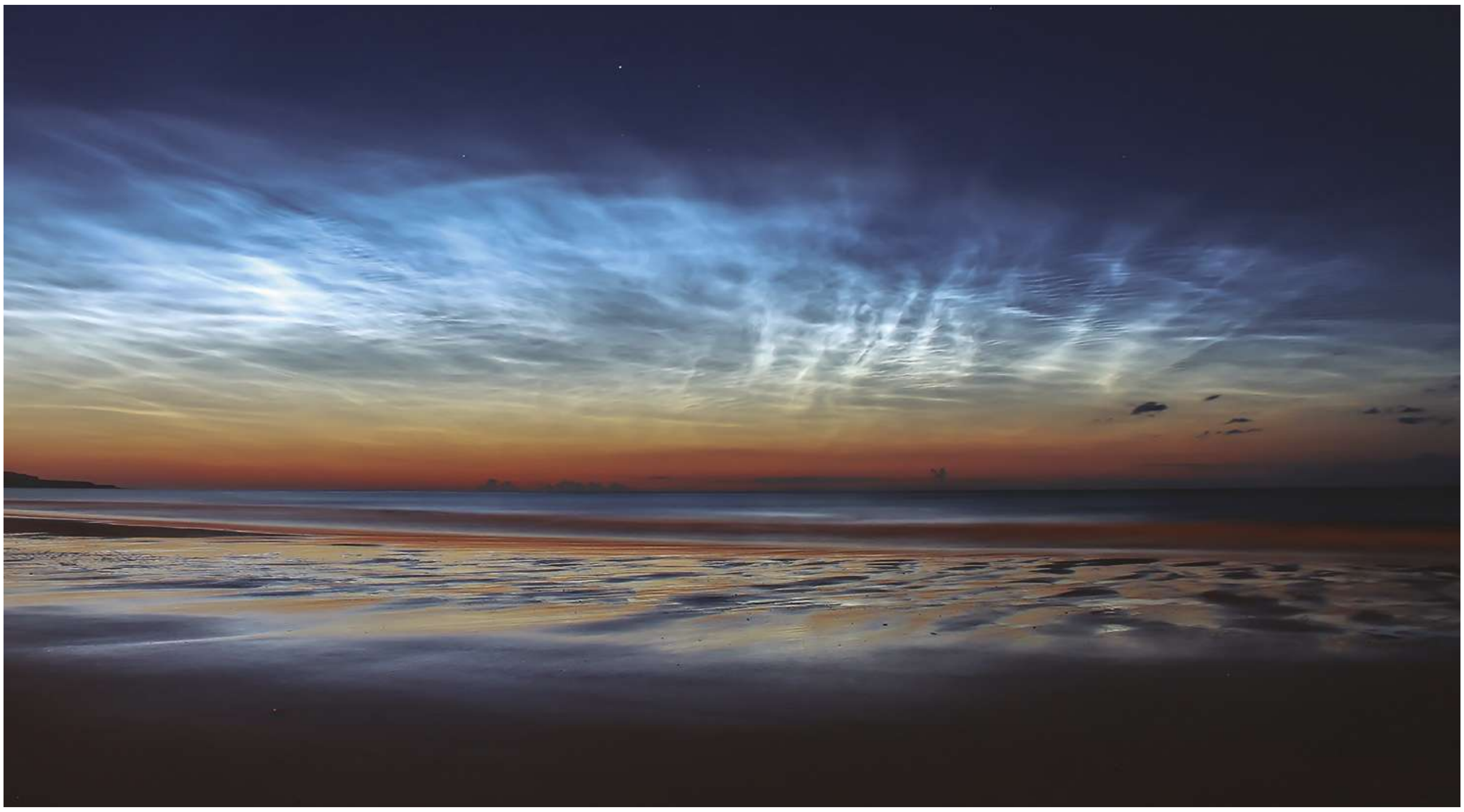
When increasing the brightness and clarity it also increases the noise in your image. This can lead to your image looking untidy with sharp edges, and less pleasing to the eye. The final stage is to reduce this using Lightroom's Noise Reduction tab. Do not be overzealous with this tool – applying too much noise reduction will mean your clouds will lose all of their structure.

These are the three key steps to getting the best out of your noctilucent cloud images. Once you have used these steps you are now close to having your finished image. You can now make any further minor edits for personal preference to get a final image that you're happy with.

Matt Robinson was runner up in the Skyscapes category of 2015's Insight Astronomy Photographer of the Year competition with this image



▲ Now work on the colours in the scene, being careful not to make it appear gaudy or unrealistic



▲ The final image feels much more dynamic and ethereal – and came runner up in the Skyscapes category of the IAPY competition in 2015

ALL PICTURES: MATT ROBINSON

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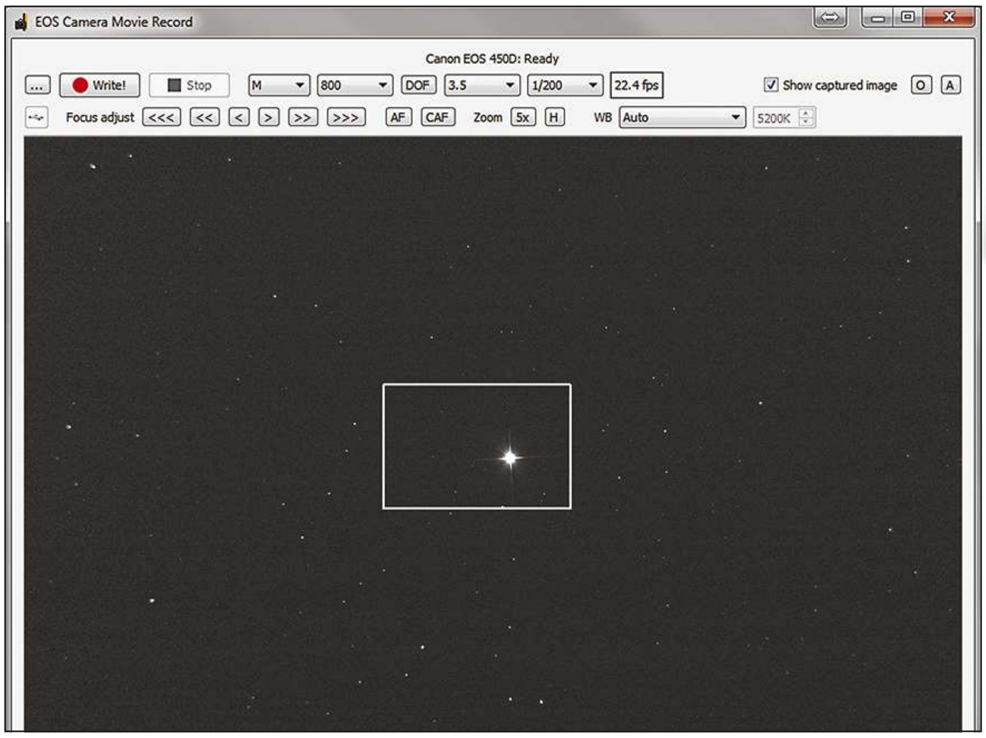

Canon EOS 450D: Ready

▲ **EOS Camera Movie Record can help you to see a sharper planet**

How do I focus my Canon EOS 60D DSLR when shooting Jupiter through my scope?

MIKE O'BRIEN

The secret to sharp and detailed planetary imaging is to use a fast frame rate camera to produce a video file that can then be stacked to produce a single high quality image using either RegiStax (www.astronomie.be/registax/) or AutoStakkert (www.autostakkert.com/), both of which are free.

Focusing a DSLR on a planet can be quite challenging, especially under typical UK seeing conditions. Often a planet will appear to shimmer and pulsate as light reflected from it is refracted by Earth's atmosphere. The live view mode can help here, but there is a much better way, using some more free software called EOS Camera Movie Record (available from https://sourceforge.net/projects/eos-movrec). This program can also be used to capture image data at a reasonable frame rate of 20-30 frames per second depending on the computer in use.

Rather than trying to focus on the planet itself, try focusing on a bright star instead, using the 5x zoom feature built into this software. Once you have the test star in focus, all other celestial objects will also be in focus, including the planets. You can now slew to Jupiter and start your image run confident that you have a good focus and, as a bonus, the 5x zoom feature can be used very successfully for the actual image capture process if required.

STEVE RICHARDS, PAUL WHITFIELD

STEVE'S TOP TIP

How do I find other astronomers in my area to share my passion for astronomy with?

Astronomy can often be a rather solitary pursuit, but without a doubt sharing your passion with others can transform your appreciation of the night sky. Joining a local astronomy club or society is a great way to meet up with other astronomers in your area and here you will find a wide range of experience and knowledge that you can learn from and contribute to. Many such organisations are members of the Federation of Astronomical Societies (FAS). Their website (http://fedastro.org.uk) should be your first port of call; all of their member organisations can be found easily under the 'Members' tab.

► **Colour filters can enhance detail on the Moon as well as the planets**

I want to observe the planets. Is it worth investing in a set of colour filters?

CLIVE MACDONALD

The use of filters for planetary observing is all about increasing contrast. Filters cannot increase the intensity of the light from these objects, but by suppressing the light you don't want they can make it easier to observe the light you do want.

Filters are commonly known by their Wratten numbers, which represent their colour. A number of filters will increase the contrast on several planetary features as well as the Moon, in particular #12 (Yellow), #21 (Orange), #25 (Red), #38A (Dark Blue), #56 (Light Green) and #80A (Blue). They would be a good basis on which to start your collection.

Buying quality filters individually can be quite expensive; sets offer better value for money. There is a set of six 1.25-inch high quality Baader filters available from £104 and these would make an excellent purchase to set you on the road. If that stretches your budget too far, an Antares 1.25-inch seven-piece colour filter set is available for £60.

Steve Richards is a keen astro imager and an astronomy equipment expert

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90

Orion's latest Go-To, the 6-inch StarSeeker IV Maksutov-Cassegrain

This month's reviews

First light

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FIRST **light**

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Orion StarSeeker IV 6-inch Go-To Maksutov-Cassegrain

A great visual observing setup that makes the most of the latest technology

WORDS: PAUL MONEY

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- **Optics** Maksutov-Cassegrain
- **Aperture** 150mm (6 inches)
- **Focal length** 1,800mm (f/12)
- **Mount** Computerised single fork arm altaz
- **Handset** SynScan V4
- **Power requirement** Eight AA batteries or 12V DC power supply
- **Extras** 23mm and 10mm eyepieces, star diagonal, 2- to 1.25-inch adaptor, EZ Finder II reflex sight.
- **Weight** 12kg
- **Supplier** Orion Telescopes & Binoculars
- **www.**oriontelescopes.co.uk
- **Tel:** 0800 8989 0123

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Looking smart with its burgundy tube livery, the Orion StarSeeker IV Maksutov-Cassegrain is a complete altaz Go-To system. It consists of a 6-inch telescope and a single-arm computerised Go-To mount with a SynScan V4 handset, mounted on a sturdy stainless steel tripod. Two 62° apparent field of view eyepieces are included (23mm and 10mm), giving magnifications of 78x and 180x. A star diagonal, a 2- to 1.25-inch adaptor and an EZ Finder II reflex sight complete the setup.

Assembly was straightforward, with the single arm mount attaching to the tripod head via three bolts and the spreader plate/eyepiece holder strengthening the tripod. The telescope attaches to the arm via a built-in Vixen-style bar. Power is provided by eight AA batteries (there's an integrated battery compartment in the mount arm) or via a 12V port at the base of the arm.

Once you power up and have entered basic details into the SynScan handset, two alignment options are available: brightest star or two star. Both worked well. Tracking did wander a little during a 20-minute session with Regulus in Leo, but the star did remain in the field of view of the 23mm eyepiece during this time.

We also used bright Regulus to check the quality of the 23mm eyepiece and were pleased to see a pin-sharp star across most of the field of view, with only slight deterioration towards the edges. The 23mm eyepiece actually gives a true field of view of 0.79 arcminutes, so just over 0.75°.

SKY SAYS…
Though primarily for visual use it can be used for limited planetary, lunar and double star imaging

Telescope on tour

We used the 23mm eyepiece to take a tour of some of the prime targets in the sky at the time of review, beginning with the Orion Nebula. With M42 framed in the centre of the view, we could see the wisps and tendrils of nebulosity extending out from the main nebula. We were able to resolve the central Trapezium Cluster and, swapping to the 10mm eyepiece, were able to see crisp stars with lots of background nebulosity.

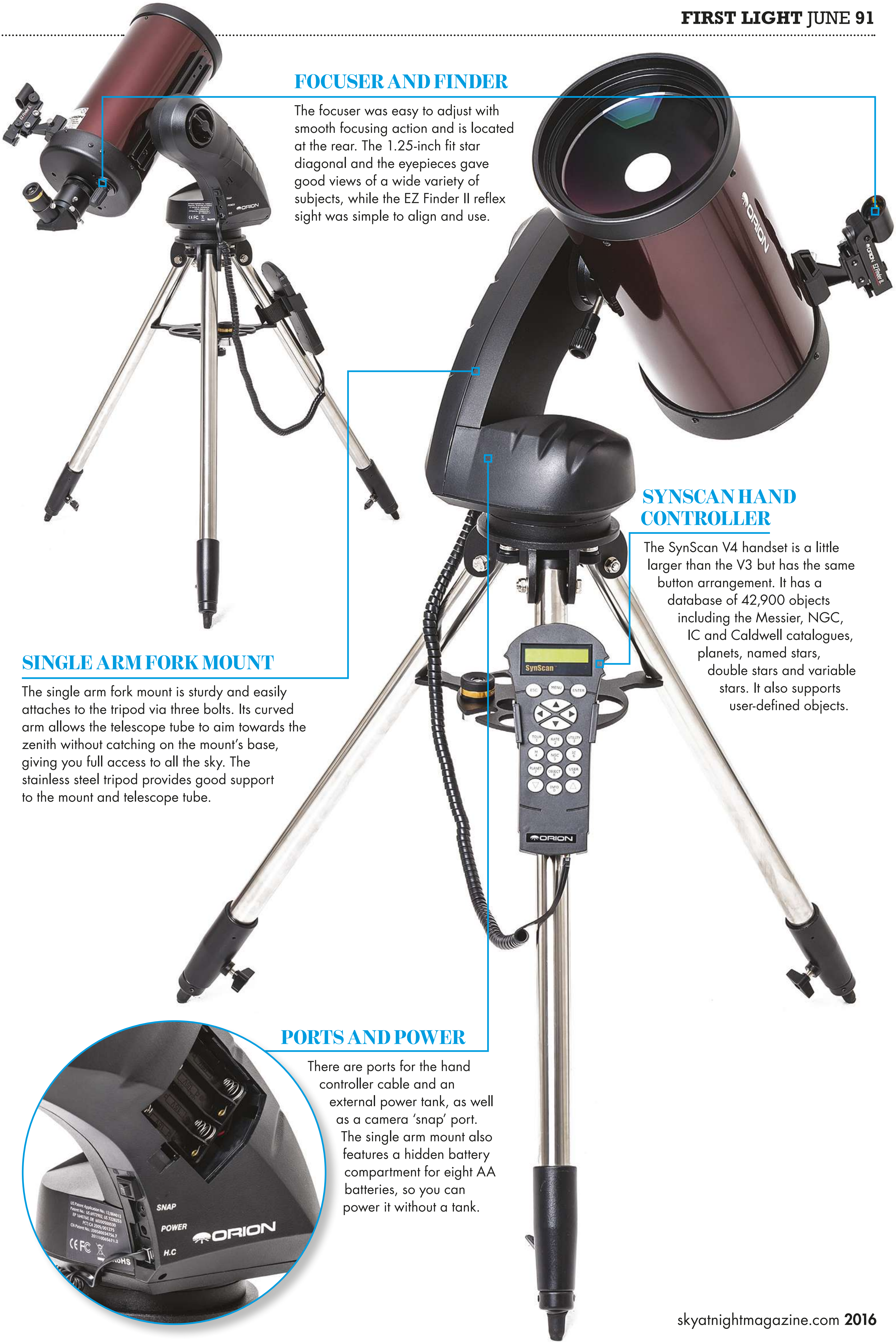
The true field of view of the 23mm eyepiece meant that galaxy pair M81 and M82 in Ursa Major only just fitted into the view. There was plenty of subtle detail in the edge-on M82 and the hazy oval disc of M81 was well seen. The 78x magnification of the 23mm eyepiece also gave good views of a range of double stars: we were easily able to split Algieba in Leo into its orange and gold components, while Castor took the guise of a lovely pair of white stars of slightly ▸

SIMPLE ALIGNMENT AND FREEDOM FIND

The SynScan V4 handset provides two alignment options, brightest star and two star. Brightest star means you can choose are area of sky from the menu and it will offer a selection of stars to align on based on the date and time. Two-star alignment allows you to select any star for the first alignment star.

The alignment options worked well depending on how far apart the initial alignment stars are from each other, with best results with stars separated by around 60°. However, regardless of which method or distance we used, we always found the target in the field of view of the 23mm eyepiece.

Additionally, encoders on the axis allow you to manually move the mount without losing alignment, something known as 'freedom find' technology. For example, use the handset to find and slew to Jupiter then manually move the mount to view Regulus in Leo. Press the option for Jupiter again and the mount will slew back to the planet. Without this feature, if you accidentally moved the mount then you would lose alignment.



FOCUSER AND FINDER

The focuser was easy to adjust with smooth focusing action and is located at the rear. The 1.25-inch fit star diagonal and the eyepieces gave good views of a wide variety of subjects, while the EZ Finder II reflex sight was simple to align and use.

SINGLE ARM FORK MOUNT

The single arm fork mount is sturdy and easily attaches to the tripod via three bolts. Its curved arm allows the telescope tube to aim towards the zenith without catching on the mount's base, giving you full access to all the sky. The stainless steel tripod provides good support to the mount and telescope tube.

SYNSCAN HAND CONTROLLER

The SynScan V4 handset is a little larger than the V3 but has the same button arrangement. It has a database of 42,900 objects including the Messier, NGC, IC and Caldwell catalogues, planets, named stars, double stars and variable stars. It also supports user-defined objects.

PORTS AND POWER

There are ports for the hand controller cable and an external power tank, as well as a camera 'snap' port. The single arm mount also features a hidden battery compartment for eight AA batteries, so you can power it without a tank.

FIRST light

SKY SAYS…
Now add these:

1. Orion Dynamo Pro 17Ah Rechargeable 12V DC power station
2. Orion 1.25-inch set of four colour filters
3. Orion SteadyPix universal smartphone telescope photo mount

OPTICS

The telescope has a focal length of 1,800mm, giving a focal ratio of f/12. It gave good views, with sharp stars across 85 per cent of the field of view through the supplied 23mm eyepiece and only minor distortion towards the edges.

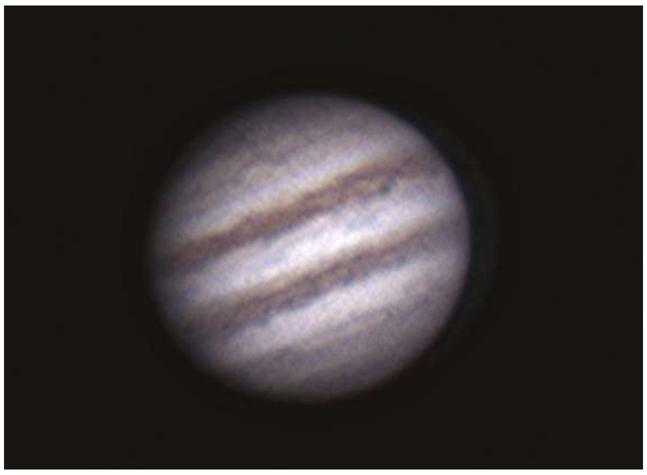
▸ unequal brightness. Changing to the 10mm eyepiece allowed us to split triple star Iota Cassiopeiae into its three components.

We had few clear periods when the Moon was visible, but the short time we had to look at it revealed plenty of detail to whet the appetite. We did, however, get to see a great view of Jupiter with its Galilean moons. The planet was crisp but small in the 23mm eyepiece, but we were able to spot all four Galilean moons in one go. Cranking up the magnification by swapping to the 10mm eyepiece, we enjoyed subtle detail along the belts, as well as the polar hoods and the Great Red Spot.

Though this setup is primarily intended for visual observing it is possible to use it for limited lunar, planetary and double star astrophotography. We attached our own CMOS camera, took several short videos of Jupiter and processed them in RegiStax: the resulting image held plenty of detail. We also recorded videos of double stars Algieba and Castor, and again produced some nice images. Ⓢ

VERDICT

BUILD & DESIGN	★★★★☆
EASE OF USE	★★★★☆
FEATURES	★★★★☆
GO-TO/TRACKING ACCURACY	★★★☆☆
OPTICS	★★★★☆
OVERALL	★★★★☆


▲ Jupiter imaged using a ZWO ASI224 CMOS camera, composed of 2,000 frames averaged and stacked

▲ Composite of the double stars Algieba in Leo (left) and Castor in Gemini, taken with the same camera

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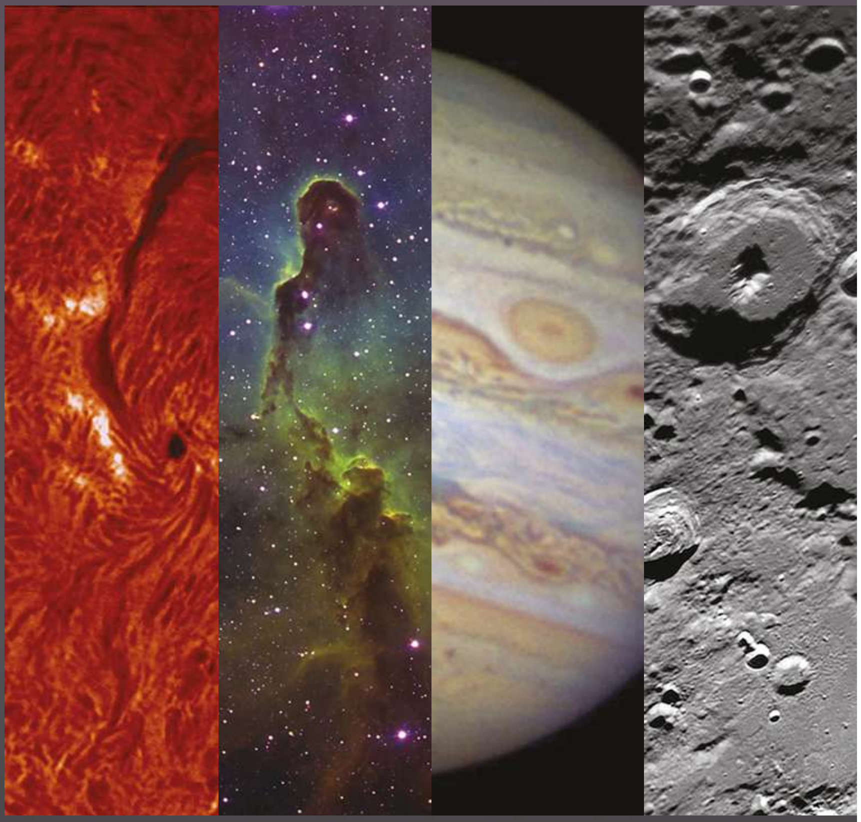

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FIRST **light**

TAP HERE For an interactive 360° model of these binos

Canon 12x36 IS III binoculars

Image stabilisation tech helps you see more of the night sky without a mount

WORDS: STEVE TONKIN

VITAL STATS

- **Price** £659.99
- **Optics** Super Spectra multicoated
- **Aperture** 36mm
- **Magnification** 10x
- **Prisms** Porro Type II
- **Angular field of view** 5°
- **Focusing** Centre focus, moving objective
- **Eye relief** 14.5mm
- **Interpupillary distance** 55-75mm
- **Weight** 660g
- **Supplier** Canon
- **www.**canon.co.uk
- **Tel** 01737 220000

SKY SAYS...

These binoculars would be suited to observers who already use a scope but also want a multi-purpose instrument

The technology of image stabilisation is undergoing continual improvement so we hoped for great things from the latest incarnation of Canon's 12x36 IS binoculars – and we weren't disappointed.

The binoculars come in a soft, slightly padded fabric case and include a wide neckstrap that we found to be very comfortable over a jacket collar. There are individual eyepiece caps that fit very well, but no caps for the objective lenses. No instruction manual is included, but the binoculars are intuitive to use and, if you decide you want a manual you can download one from Canon's website.

The binoculars are covered with matt rubber armour which gives a secure grip and offers some protection in normal use. The prism system is a Porro Type II, which means that you adjust the interpupillary distance by rotating the entire eyepiece assemblies. They move smoothly, with enough resistance to ensure that they will not accidentally slip once they have been set. The same applies to the right eyepiece dioptre adjustment, which has a range of ±3 dioptres. Centre focus is light and smooth. The binoculars are neither waterproof nor nitrogen filled.

The eyecups fold down to below the surface of the eyepieces, so the full 14.5mm eye relief is available, but we found that this was inadequate for some spectacle wearers, who were unable to see the full field of view. The focal range of the binoculars extends several dioptres 'beyond' infinity, so most people with focus defects of their vision should be able to observe without their glasses. The narrow eyepiece barrels make it very easy to find the optimal position for your eyes.

Champion coatings

When you hold the binoculars up to the light, the exit pupils appear perfectly round, with no cut-offs or grey segments, indicating that the prisms are fully sized and that the glass used has an appropriate refractive index. Canon has not specified the extent of its proprietary 'Super-Spectra' multicoatings, but when we shone a light down the objective end there was minimal light reflected from its surface, while the bright white light reflected from an internal component suggested that not all glass-air optical surfaces are coated.

When we observed the Moon and Jupiter (or held them just outside the field of view) there were no spurious ghost images, so the coatings are certainly fit for purpose. The control of stray light is excellent. Chromatic aberration was minimal, although visible on bright objects when off-axis.

When we focused on the Pleiades open cluster in Taurus the image was flat and crisp almost to the ▸

EXCELLENT IMAGE STABILISATION

Canon has continuously improved its Vari-Angle Prism image stabilisation system since it was introduced in 1990s. Earlier implementations took several seconds to stabilise the image and even then the resulting view was frequently afflicted with a 'swimming' sensation and reduced sharpness.

The new generation of motion sensors obviously respond exceptionally quickly to any motion or vibration and, as a consequence, the image settles down quickly and is remarkably steady. In the Canon 12x36 IS III, the image stabilises within one second and we were unable to get it to 'swim' even when we tried to induce this by deliberately vibrating the binoculars. Nor were we able to detect any reduced sharpness.

The somewhat surreal result of trying to fool the image stabilisation system was a perfectly steady view surrounded by shaking binoculars. The Vari-Angle Prisms can correct for up to 0.8° deflection, so the image stabilisation system can deal with unsteadiness of a greater amplitude than most people have.

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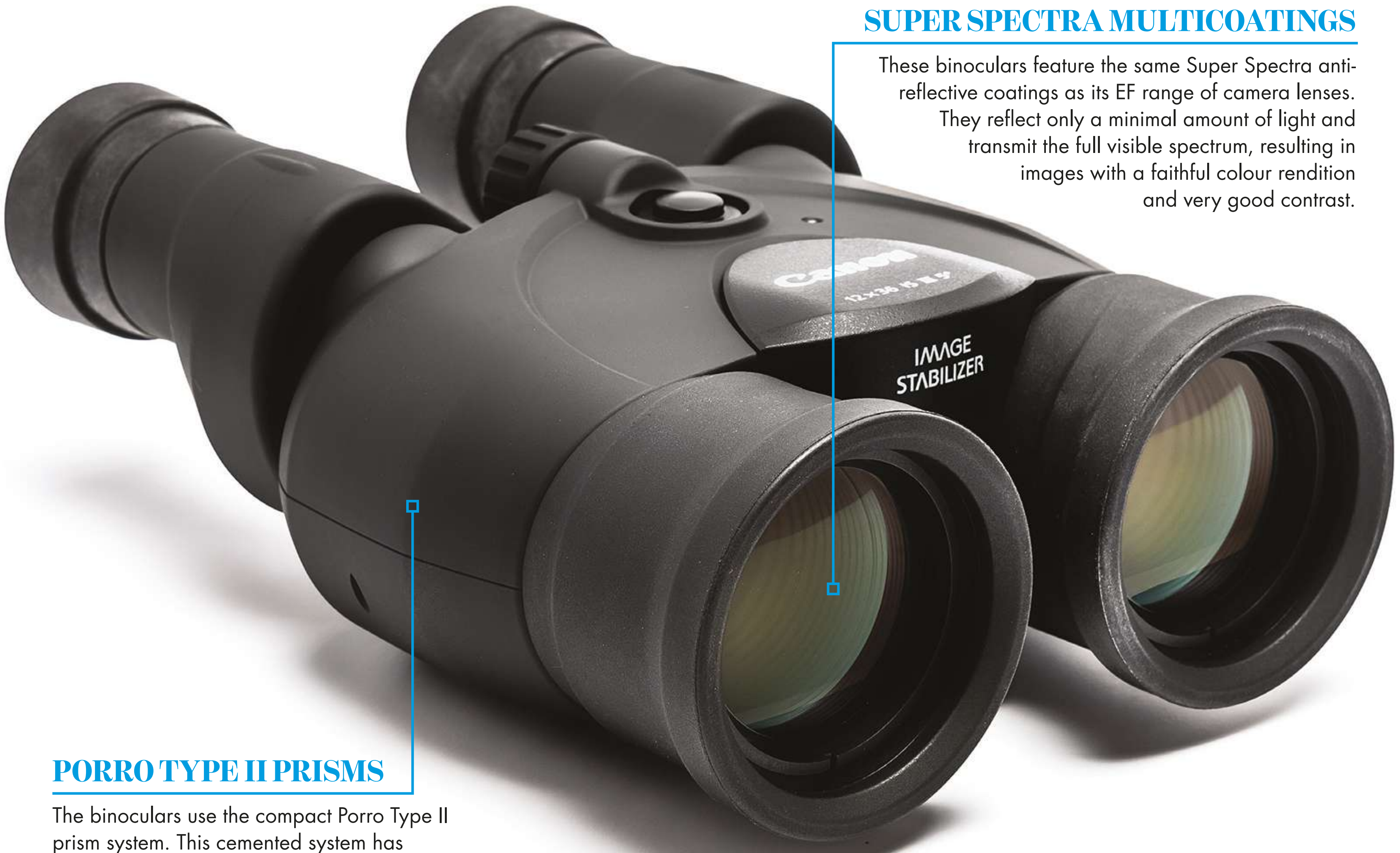


SUPER SPECTRA MULTICOATINGS

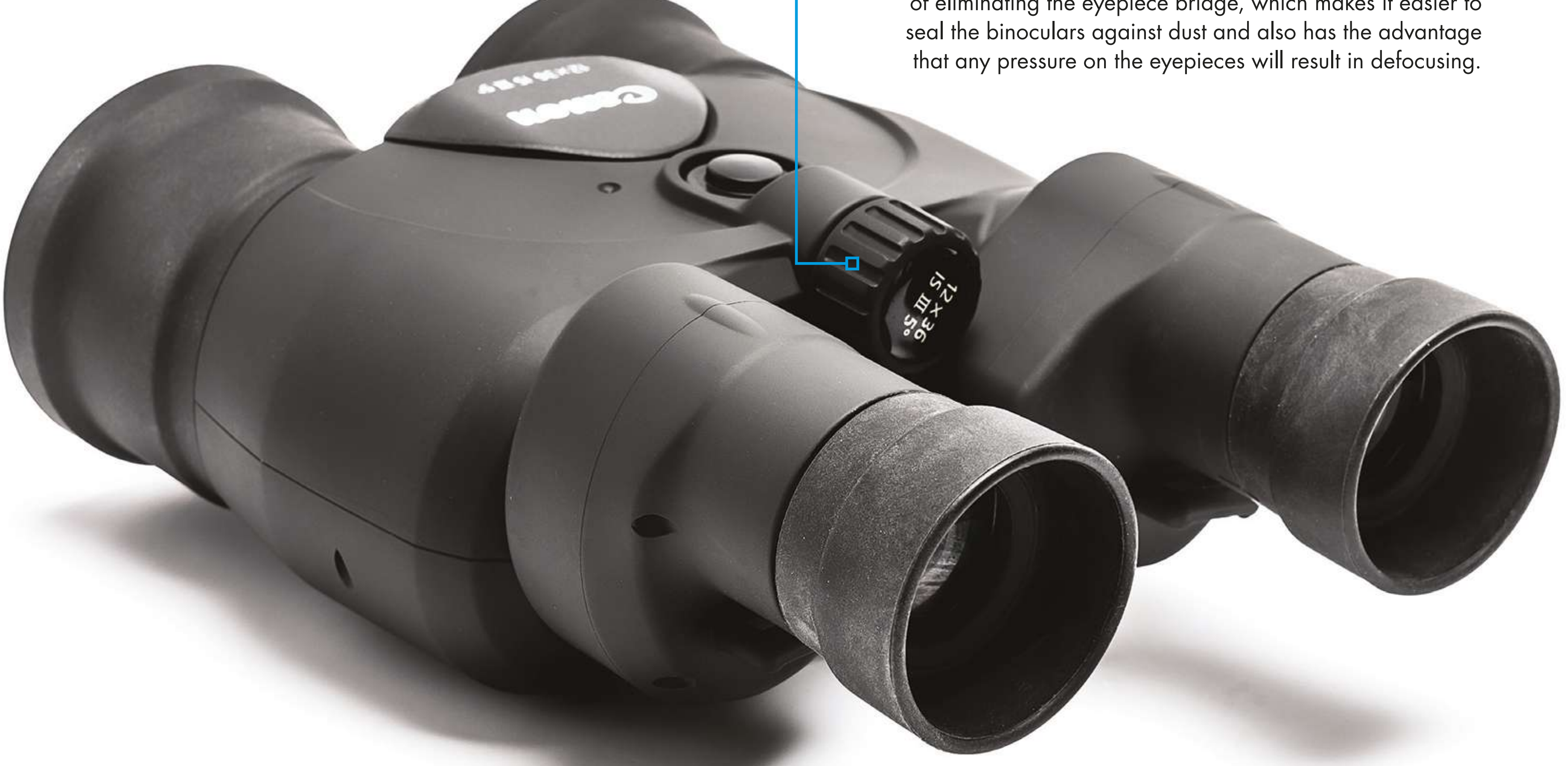
These binoculars feature the same Super Spectra anti-reflective coatings as its EF range of camera lenses. They reflect only a minimal amount of light and transmit the full visible spectrum, resulting in images with a faithful colour rendition and very good contrast.

PORRO TYPE II PRISMS

The binoculars use the compact Porro Type II prism system. This cemented system has several advantages over the more common Porro Type I prisms: as well as allowing a greater interpupillary distance range, it offers increased light transmission and fewer surfaces where chromatic dispersion, light scatter and spurious reflections can occur.

OBJECTIVE LENS FOCUSING

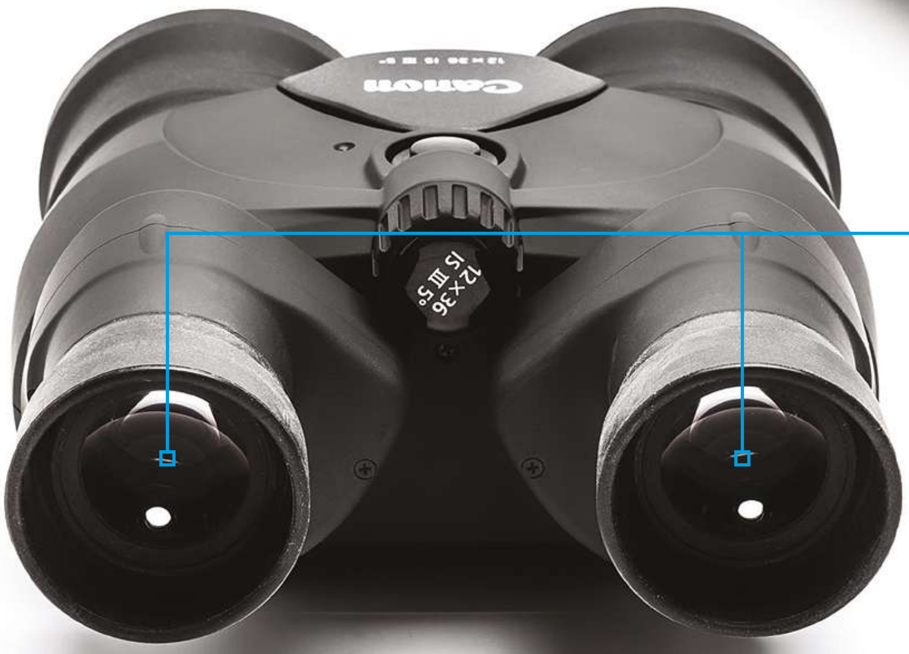
The focusing mechanism works by moving the objective lenses inside the binocular body. This has the advantage of eliminating the eyepiece bridge, which makes it easier to seal the binoculars against dust and also has the advantage that any pressure on the eyepieces will result in defocusing.



FIRST light

BATTERIES

Image stabilisation is powered by two AA batteries, with a specified life of nine hours at 25°C, falling to one hour at –10°C. These batteries are readily available, so you would be very unlikely to be caught out in a situation where they have run out of power and you could not source a replacement.



GOOD INTERPUPILLARY DISTANCE RANGE

With an interpupillary distance of 55-75mm, these binoculars offer great flexibility. The narrow eyepiece barrels mean that there is 17mm between the soft rubber eyecups at the minimum interpupillary distance, so they should comfortably fit even the smallest of faces.

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SKY SAYS...
Now add these:
1. Lens cleaning kit
2. Spare AA batteries
3. Sun lounger for viewing comfort

▸ edge, a testament to the efficacy of the field-flattener lens in the optical train. We then pressed the button to engage the image stabilisation and, not only did the image become stock-still, but fainter stars became visible. We did not quantify this, but estimate that the binoculars give approximately another 0.25 magnitudes of depth without the need for any bulky mounting system.

With an aperture of 36mm, the laws of optics limit the usefulness of these binoculars when it comes to faint deep-sky objects, but the image stabilisation certainly helped to extract structural detail from the Orion Nebula. But the most severe test we gave the binoculars was observing Jupiter's Galilean moons when Callisto and Europa were each only 40 arcseconds from Ganymede. When the seeing became steady, not only was it obvious that there were three moons but, on the other side of Jupiter, a mere 37 arcseconds from Jupiter's disc, Io was also fleetingly visible despite the brightness of the planet.

The Canon 12x36 IS III binoculars would be best suited to observers who already use a telescope or larger binoculars as their main instrument, but also want a single multi-purpose instrument. Certainly these binoculars could easily be used for terrestrial purposes as astronomical ones. Ⓢ

VERDICT

BUILD & DESIGN	★★★★★
EASE OF USE	★★★★★
FEATURES	★★★★☆
IMAGE STABILISATION	★★★★★
OPTICS	★★★★☆
OVERALL	★★★★★

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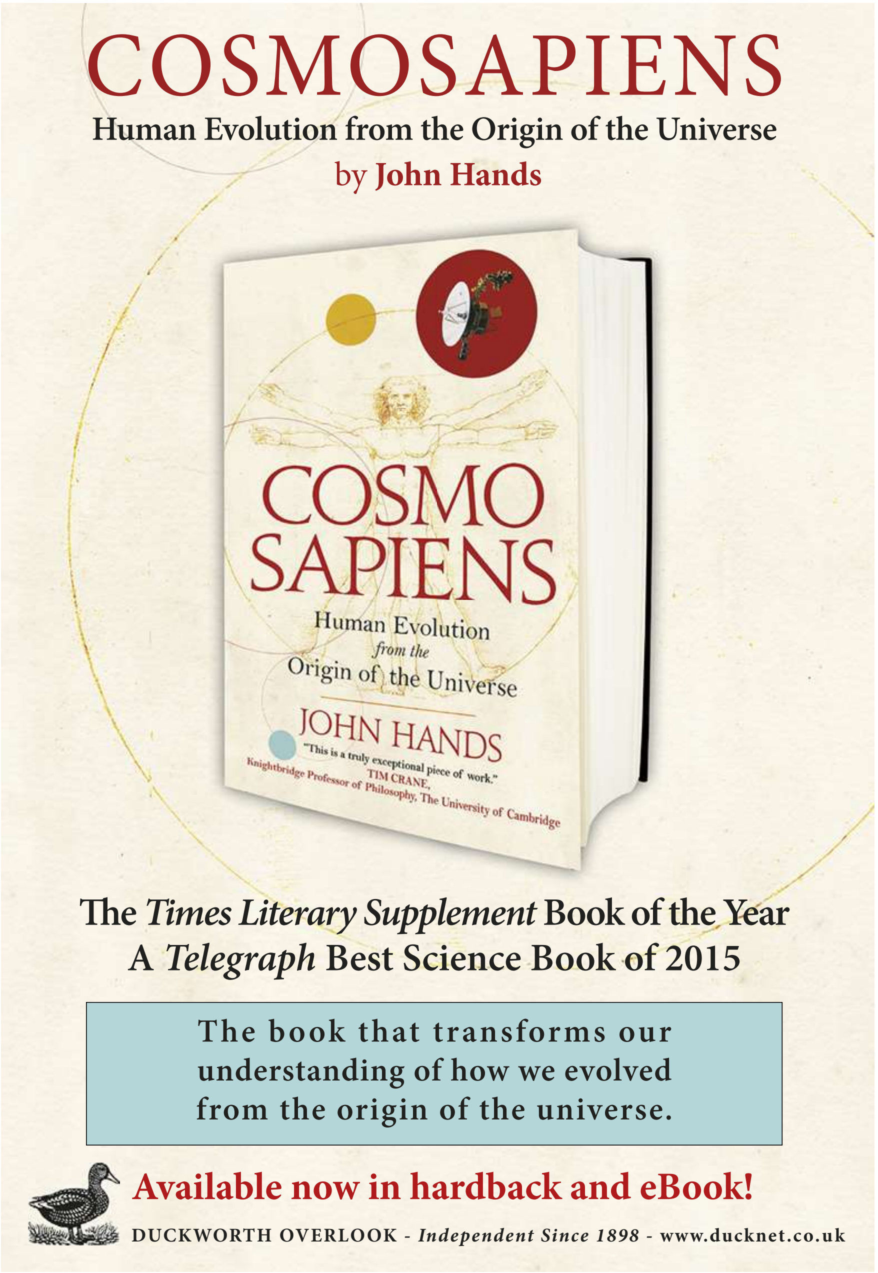
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FIRST **light**

TAP HERE For an interactive 360° model of these eyepieces

Altair Kitakaru eyepieces

A trio of orthoscopic oculars that offer a wider than usual apparent field of view

WORDS: STEVE RICHARDS

VITAL STATS

- **Price** £105-£139.50
- **Focal length** 25mm, 30mm, 45mm
- **Apparent field of view** 62°
- **Eye relief** 14mm
- **Optical elements** 4
- **Barrel size** 1.25 inches (25mm only), 2 inches (30mm and 45mm)
- **Supplier** Altair Astro
- **www.altairastro.com**
- **Tel** 01263 731505

SKY SAYS...
The eyepieces didn't disappoint but are unsuitable for fast scopes without a Barlow lens or coma corrector

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There is a clear movement towards producing eyepieces with ever wider apparent fields of view, but in many cases this can be a distraction, taking your mind off the main event. Altair has taken a different approach with its trio of Kitakaru orthoscopic eyepieces, concentrating on a more modest apparent field but with long focal lengths to encompass a wide expanse of sky.

The eyepieces have focal lengths of 25mm, 30mm and 45mm. The 25mm version has a 1.25-inch barrel and the other two have 2-inch barrels. Each is finished in an electric red anodised coating over a lightly sandblasted and slightly conical body, with contrasting black trim and white lettering to indicate the focal length.

These oculars are designed for longer focal length telescopes so we used a 2x ED Barlow lens with our own 4-inch, f/6.5 refractor to produce an effective focal length of 1,238mm. They are not fully parfocal, but a small focus adjustment was all that was required to refocus between eyepiece changes, making comparisons between each quick and easy.

Eye relief is the fixed distance from the curved surface of the outermost lens of an eyepiece to the point at which the exit pupil is formed. The 45mm eyepiece had a much longer eye relief at 22mm than the two shorter focal length eyepieces and we didn't suffer from any eye placement issues. Colour control was excellent right out to the last 10 per cent of the field of view, where a small purple tinge started to appear on bright stars. Star shapes were excellent to over 85 per cent of the field of view.

The field stop of the 45mm eyepiece was not quite as well defined as for the other two. We used Aldebaran in Taurus as our test star and while in the region examined the huge Hyades star cluster, which was excellent in this eyepiece, as was the open cluster Melotte 20. However, the Pleiades in Taurus and the Beehive Cluster in Cancer stole the show – we can safely say this is an excellent choice for observing open star clusters.

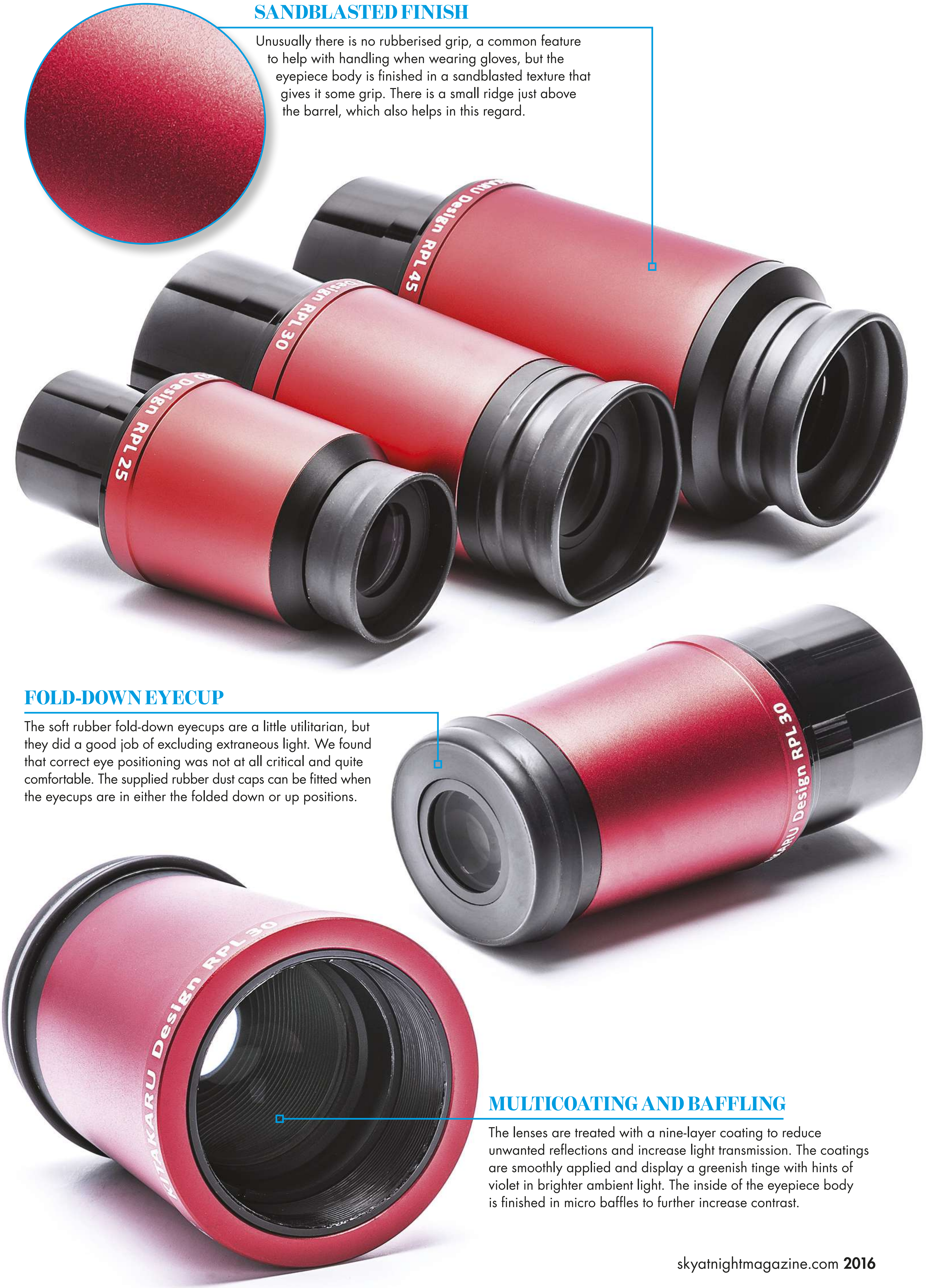
Slight variances

The 30mm eyepiece performed better in our star test with well-defined stars and colour control out to over 90 per cent of the field of view, with just a tinge of purple making its presence known at the extreme field edges. The field stop was well defined with just a hint of a yellow tinge. The galaxy duo of ▸

A SMART UPDATE TO AN OLD DESIGN

Orthoscopic (producing an image with correct and normal proportions) eyepieces are so called because of their low levels of distortion, especially with regard to pincushion and barrel distortion. Designed by Ernst Abbe in 1880, such eyepieces have four lens elements, but their disadvantage is that they produce a rather narrow apparent field of view, typically 40-45°. This, however, is no impediment to lunar and planetary observing for which they have always been popular. Altair's Kitakaru eyepieces are a modified orthoscopic design, resulting in a much wider apparent field of view of 62° – and so maintaining some appeal for observers more used to wider fields.

The long focal lengths of these three eyepieces makes them less suitable for planetary observations but of more interest when observing larger celestial objects; they are also excellent for lunar observations when used with a long focal length telescope such as a Schmidt-Cassegrain. They perform at their best when coupled to telescopes with slower focal ratios greater than f/7.



SANDBLASTED FINISH

Unusually there is no rubberised grip, a common feature to help with handling when wearing gloves, but the eyepiece body is finished in a sandblasted texture that gives it some grip. There is a small ridge just above the barrel, which also helps in this regard.

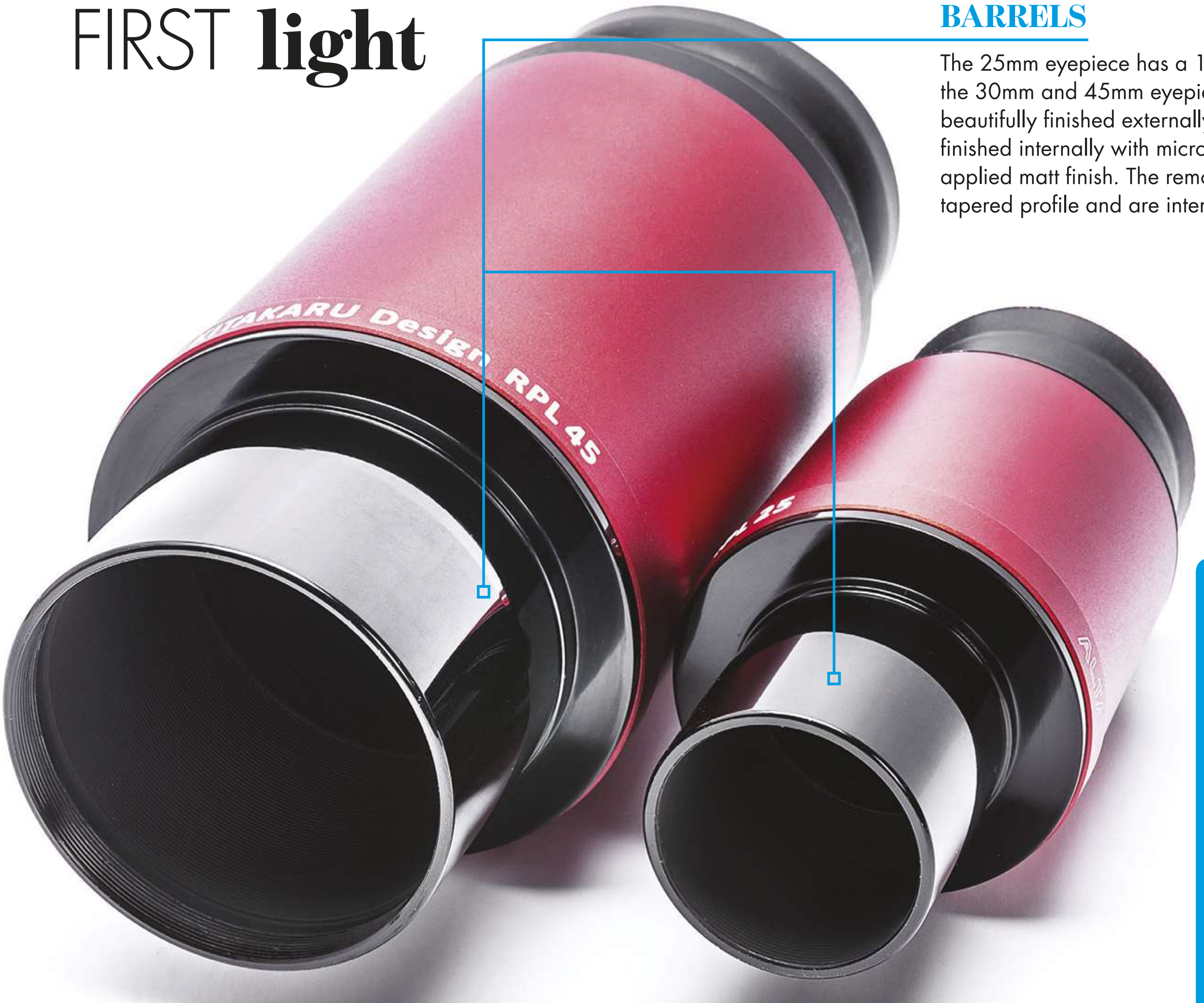
FOLD-DOWN EYECUP

The soft rubber fold-down eyecups are a little utilitarian, but they did a good job of excluding extraneous light. We found that correct eye positioning was not at all critical and quite comfortable. The supplied rubber dust caps can be fitted when the eyecups are in either the folded down or up positions.

MULTICOATING AND BAFFLING

The lenses are treated with a nine-layer coating to reduce unwanted reflections and increase light transmission. The coatings are smoothly applied and display a greenish tinge with hints of violet in brighter ambient light. The inside of the eyepiece body is finished in micro baffles to further increase contrast.

FIRST light



BARRELS

The 25mm eyepiece has a 1.25-inch barrel and the 30mm and 45mm eyepieces have 2-inch barrels, beautifully finished externally in a black gloss but finished internally with micro baffles and a well-applied matt finish. The removable barrels have a tapered profile and are internally threaded for filters.

SKY SAYS...
Now add these:

1. Altair CLS filter
2. Altair DewZapper 2-inch dew heater
3. Altair Lightwave Premium 2-inch diagonal

▸ M81 and M82 in Ursa Major were a perfect fit and such a pleasure to see together so well defined. M34 in Perseus was a treat and Orion's Sword looked spectacular, but the highlight was our best ever view of the Double Cluster. With the naked eye, the 15mm eye relief was fine but was more challenging when wearing spectacles even with the eyecup folded down.

The last ocular was the 25mm, a popular choice with manufacturers and many telescopes are supplied with one as standard. These are generally of adequate quality but this one represents a big step up, providing excellent star shapes out to over 90 per cent of the field of view with excellent colour control, though again producing a slight purple tinge to stars at the very edge. We couldn't detect any difference in eye relief between this and the 30mm eyepiece (although at 14mm, it has the shortest relief of the eyepieces on test) and the field stop appeared very similar too. We used it to observe Jupiter and its moons, and it produced a very crisp view, albeit at a very small scale. However, it revealed the full field of the Leo Triplet of galaxies, the view of globular cluster M3 in Canes Venatici was excellent and the 2.5-day-old Moon showed exquisite detail.

These eyepieces didn't disappoint but you should bear in mind that they are unsuitable for fast focal ratio telescopes unless you use a Barlow lens (for a refractor) or a coma corrector (for a reflector). They're best suited for intermediate observers, especially those with a Schmidt-Cassegrain or similar long focal length telescope. Ⓢ

EYE RELIEF

The eye relief varies between the three eyepieces, with a generous 22mm for the 45mm variant, 15mm for the 30mm and 14mm for the 25mm. The 45mm is very suitable for spectacle wearers but the 30mm and 25mm are somewhat harder to use while wearing glasses; all three were fine without.

VERDICT

BUILD & DESIGN	★★★★★
EASE OF USE	★★★★☆
EXTRAS	★★★★☆
EYE RELIEF	★★★★☆
OPTICS	★★★★☆
OVERALL	★★★★☆

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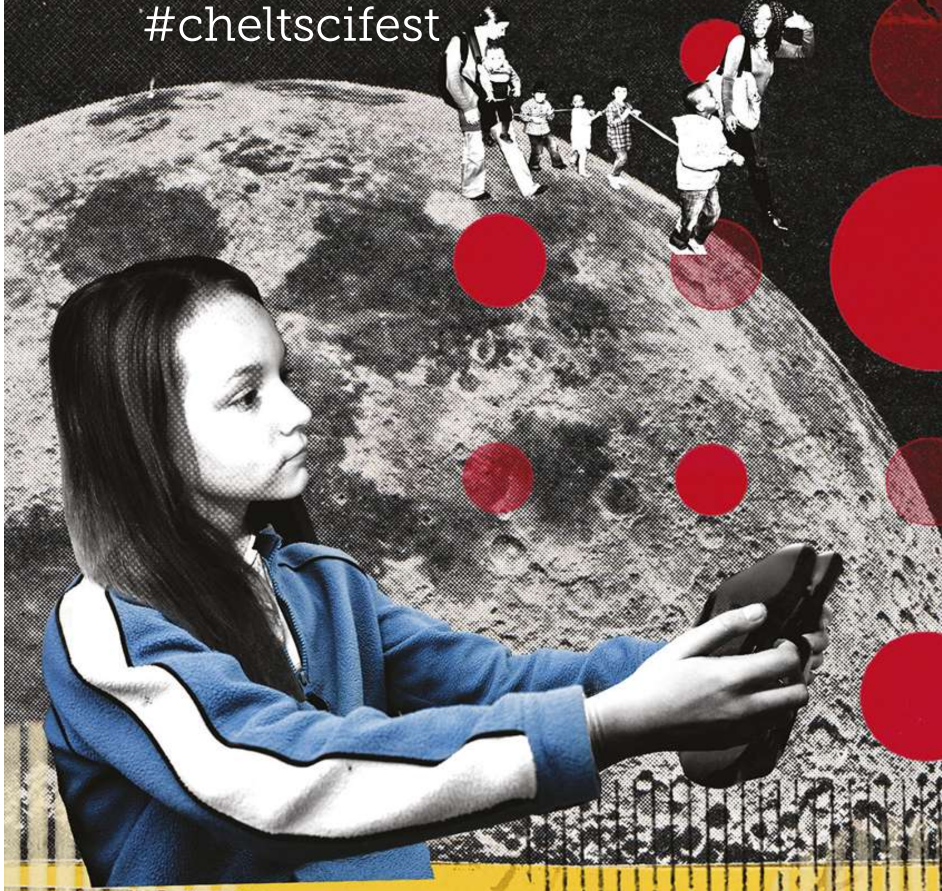

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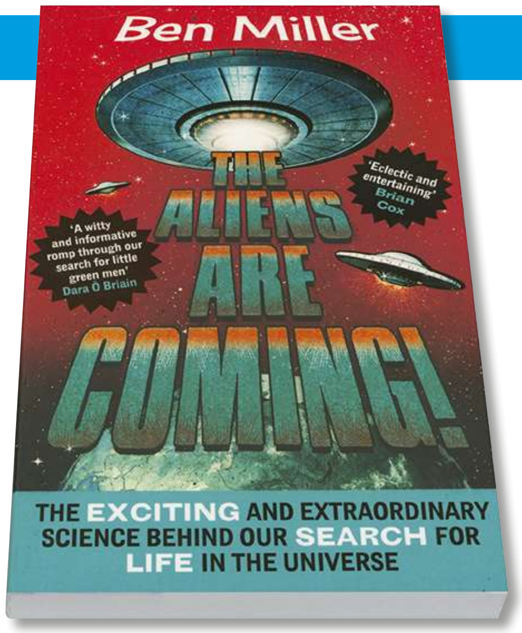
Books

New astronomy and space titles reviewed

RATINGS

★★★★★ Outstanding
★★★★☆ Good
★★★☆☆ Average
★★☆☆☆ Poor
★☆☆☆☆ Avoid


Ben Miller
THE ALIENS ARE COMING!
'Eclectic and entertaining' Brian Cox
'A witty and informative romp through our search for little green men' Dara Ó Briain
THE EXCITING AND EXTRAORDINARY SCIENCE BEHIND OUR SEARCH FOR LIFE IN THE UNIVERSE

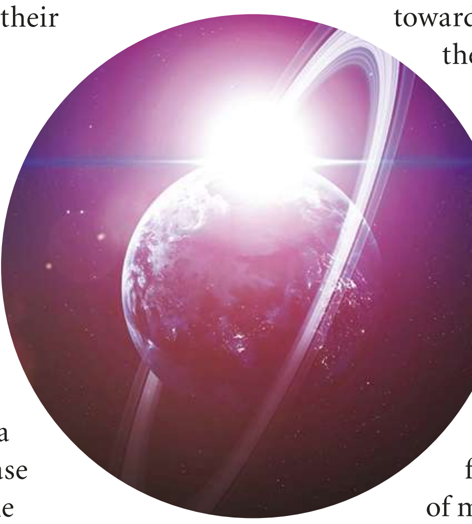
The Aliens Are Coming!

Ben Miller
Sphere
£12.99 ● PB

Ben Miller, actor, comedian and self-professed mutant ape living on a ball of molten iron, tackles the greatest question of all: is there life beyond Earth?

Writing in an engaging style, over the course of this book Miller whisks us from the depths of the Pacific Ocean to supersized exoplanets, and there are some wonderful set pieces along the way. For instance: how using the Drake Equation to calculate the number of communicating alien civilisations in the Galaxy is much like Dire Straits playing their encore hit in Wembley Arena in 1985, gazing out at an audience of swaying lighters.

When discussing the precise values of the physical parameters of our Universe that have allowed life to emerge, Miller vividly imagines a toy universe in a glass case with a row of dials on the base. Fiddle with these settings and hit the go button again, and Miller visualises for us how weird potential universes could be, and thus how finely tuned our own appears to be for allowing biology.


Confused by the Drake Equation? Break out the Dire Straits, says Miller

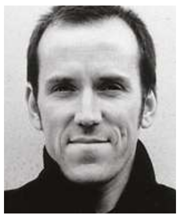
ISTOCK

Often the advantage offered by a non-specialist writer is that he or she is able to approach the subject with an enticing freshness, exploring a new field at the same time as the reader. This external perspective helps to zero-in on what is fascinating and thought provoking to the layperson, and to not miss the forest for the trees (as can sometimes beset expert writers). On the other hand, however, the risk is that without that depth of background understanding, errors and misrepresentations creep into the text, or the overview is skewed towards the viewpoints of the few scientists interviewed during the research.

The Aliens are Coming! comprehensively covers topics like SETI, and one of the competing theories for the origins of life, but feels decidedly neglectful of many other current areas in the search for life elsewhere. For example, more pages are devoted to Napoleon and Egyptian hieroglyphics than the prospects of life on Mars, Europa and Titan combined. Though this is, ultimately, a minor gripe: overall Miller writes with a delightful wit that makes this book absolutely compelling reading.

★★★★☆

DR. LEWIS DARTNELL *is an astrobiology research fellow and author*



TWO MINUTES WITH BEN MILLER

What questions does the book seek to answer?
It's really an opportunity to explore some of the interesting aspects of the notion of life. What is life? How did it start? Is this the only intelligent life that exists in the Universe and, if it isn't, what is other life like? We've come a long way to answer some of those questions and lots of different branches of science are joining in the search. If I had tried to write this book even five years ago it would have been ridiculed! But things are moving so fast that the science of extraterrestrials is something people are now starting to take seriously.

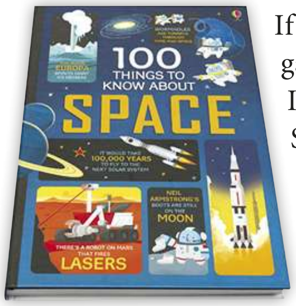
What might intelligent life look like, if we do find it?
One of the interesting things about evolution is that it not only produces different species, but it also often finds the same solutions to problems: so limbs, eyes, teeth and scales crop up on all branches of the animal family tree. We could expect that alien life might also have eyes and ears and the other traits that we find on Earth, just not necessarily in the same order.

Can we expect to find alien life soon?
The speed of the search is increasing at an extraordinary rate. Frank Drake, who began searching for radio signals in the 1960s, managed to search just a handful of stars, whereas we are aiming to search a million stars over the next 10 years. So we are only really just beginning to sample a big enough portion of the Galaxy to get an answer as to whether there is any other technologically advanced alien life out there.

BEN MILLER *is an actor, comedian, director and author*

100 Things to Know About Space

Alex Frith, Alice James, Jerome Martin
Usborne Publishing
£9.99 ● HB



If your kids have ever gazed up at the International Space Station and asked you how fast it's moving, or how astronauts scratch their noses during spacewalks, this is the book for them.

In this graphic non-fiction title, each page presents a different nugget of information illustrated with cheerful cartoons. The range of facts is impressively wide, covering astronomy, space exploration and the technology behind it.

As well as science, the book includes brief biographies of relevant people. The cartoons are gender-balanced – important in a children's book on a traditionally male-dominated subject – and it was nice to see one of a man in a wheelchair pondering the very beginning of the Universe – not named as Hawking but clearly identifiable as such!

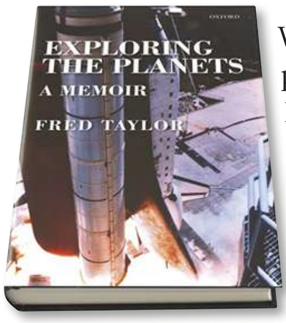
There is no obvious order to the book, however: for example one page describes the merging of galaxies, the next explains how water is recycled on the ISS. This gives a feeling of constantly discovering new facts on every page, but also means that the experience of reading it can be slightly disorientating. The randomness of *100 Things to Know About Space* in this respect means it is a title that is perhaps easier to dip in and out of, rather than attempting to read from cover to cover, and that may help it appeal to younger children with shorter attention spans.

In a book with relatively few words and in which each sentence has to do a lot of work, the information conveyed is necessarily simplified, but never inaccurate. Above all it's fun, and will no doubt help inquisitive children learn a bit more about the 'world' of space.
★★★★☆

PIPPA GOLDSCHMIDT *is a science writer and astronomer*

Exploring the Planets: A Memoir

Fred Taylor
Oxford University Press
£25 ● HB



When British planetary scientist Fred Taylor was born in September 1944, V2s were raining down on London. When he retired in 2011, his instruments had flown to five planets, the Moon and a comet, thanks to science derived from German rocket technology.

For over two decades, Taylor was head of atmospheric, oceanic and planetary physics at the University of Oxford. Before that, he worked at NASA's Jet Propulsion Laboratory in California for 10 years. *Exploring the Planets: A Memoir* is his very personal recollection of half a century of exciting planetary science, including many triumphs as well as a number of tragedies.

Taylor is a great storyteller and a skilful writer. His book provides a captivating behind-the-scenes-look at space astronomy, brimming with funny anecdotes but really focusing on the many missions he has been involved with, from the 1978 Pioneer Venus Orbiter (for which Taylor was principal investigator) through great projects like Galileo and Cassini and on to more recent endeavours such as Rosetta and ESA's upcoming BepiColombo mission to Mercury. Taylor's chapter on climate change then brings his expertise on planetary atmospherics back home to our own planet.

The many personal photographs (including lots of pictures of great cars – Taylor's second passion) give a nice human touch, although I would have loved more and better reproduced science images. All in all this is a rich and illuminating book – a must-read for everyone interested in planetary science or considering a career in space exploration.
★★★★☆

GOVERT SCHILLING *is an astronomy writer and author*

International Space Station: Architecture Beyond Earth

David Nixon
Circa Press
£65 ● HB

BOOK OF THE MONTH

It takes the education and practice of an accomplished architect to really bring home the soul and warmth of humanity's aspiration to be a truly spacefaring species, the International Space Station being the first toehold as we build out into the Solar System.

Using lavish, breathtaking visuals it explores the history of space stations by weaving human spaceflight and the evolution of engineering, bringing the reader up to speed on what a remarkable feat the ISS is. It immerses the reader in ISS activities and systems, but without labouring through countless plots and charts.

Astronaut Nicole Stott's introduction shows that astronauts are people, like any of us, but with a very specialised job to do in a unique facility orbiting the Earth that sees many sunrises and sunsets every day. The sights and smells, food and noise she describes are the next best thing to being there. She points out that even though designs might vary from Russian capsule to American module, from the homely and cosy to the hardedge technical, the ISS is an integral, complex machine that keeps her crew safe and productive.

This book should be essential reading for a wide audience – anyone who wants an insight into the field of human spaceflight in general, and the ISS in particular.
★★★★☆

MADHU THANGAVELU *is a lecturer in space architecture at the University of Southern California*

Gear

Elizabeth Pearson rounds up the latest astronomical accessories

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2

3

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www.thebinocularshop.com

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2 Aurora Sours Apple Cubes

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http://shop.rmg.co.uk

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3 Varius Power Supply Hub

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4 Hemisphere Necklace

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5 Celestron Elements TrekCel 2200

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6 Astronomik Pro-Planet 742 Filter

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4

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6

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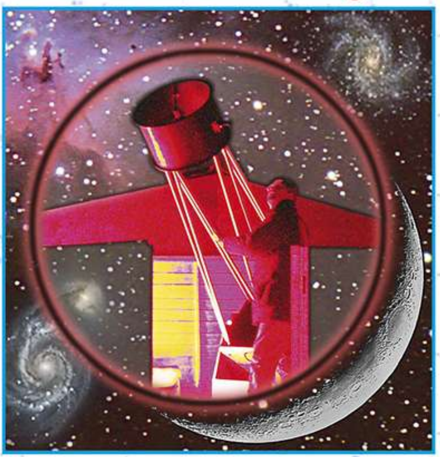

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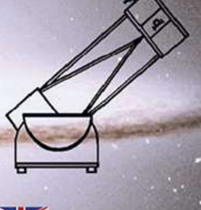

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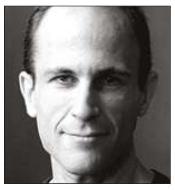
WHAT I REALLY WANT TO KNOW IS…

What can X-rays tell us about a star's age?



Eric Blackman is comparing characteristics of stars like our Sun to get a more accurate fix on how they evolve

INTERVIEWED BY PAUL SUTHERLAND

Advances in observational techniques and instrumentation in recent years have allowed astronomers to learn much more about the physical properties of stars. I have been carrying out research to see whether some of these properties might allow us to determine the age of Sun-like stars more precisely.

The Sun shines mostly in optical light, but it also emits X-rays. The Sun's X-ray emission is about a million times less powerful than in the optical. Where do the X-rays come from? It is thought they are the result of the dissipation or annihilation of magnetic energy on the Sun.

This is important because we know the Sun is a giant magnet, and we know there is a solar cycle of magnetic activity that varies every 11 years. This cycle is also linked to the number of sunspots visible on the Sun's surface. When it is strongest, there are also lots of sunspots – that is, places where the magnetic field is popping up and entering the Sun's atmosphere, or corona. There is also correlation with the X-ray luminosity. When the magnetic field is strongest, the X-rays are also most prevalent. You get more X-rays and also more flares on the Sun's surface.

Order from disorder

How does this turbulent 'ball of fire' produce these ordered, large scale magnetic fields? How do you get order from disorder, and how does the magnetic energy get turned into X-rays? They are questions I've been interested in for a while, along with how it fits into our study of stars in general.

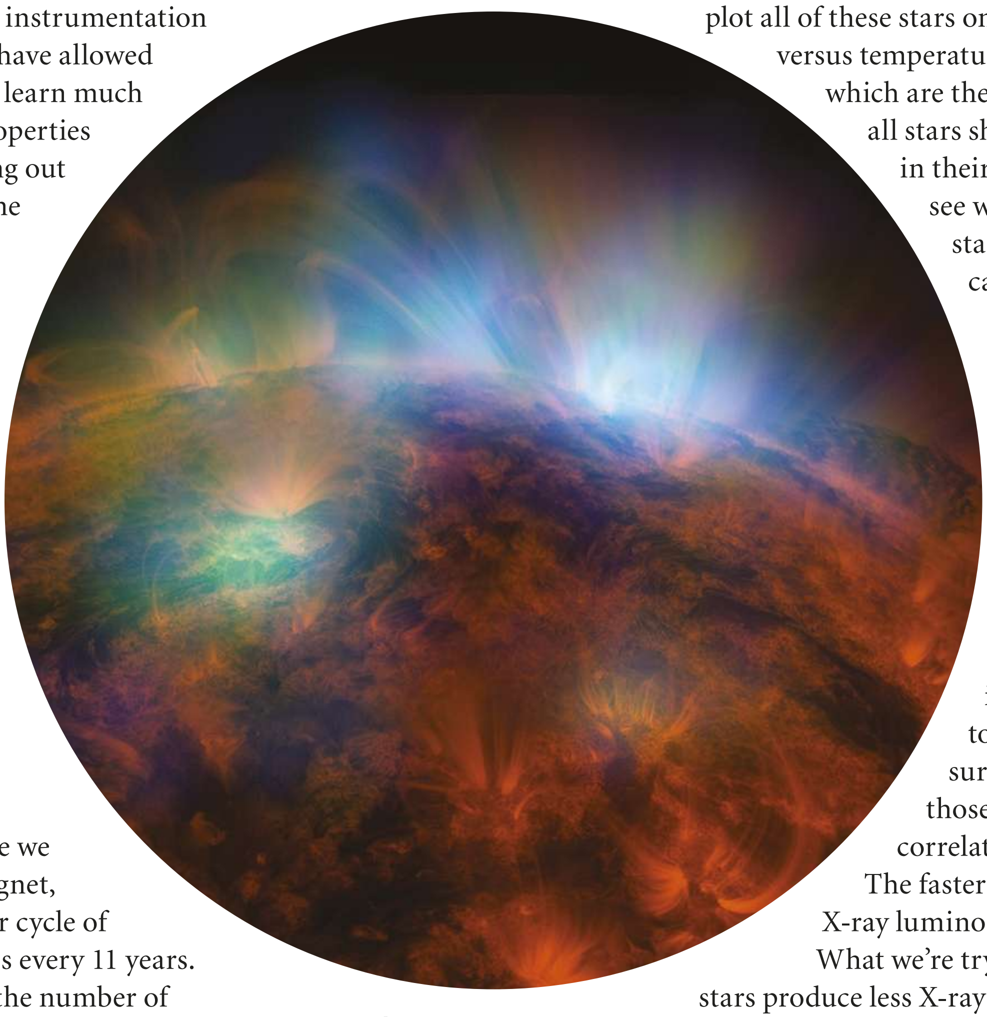
A useful way to compare stars is to examine the members of a star cluster, which may contain between 1,000 and 1,500 stars with different masses and diameters. We can predict how their luminosities, temperatures and emission spectra evolve as a function of age very well. So, we can plot all of these stars on a graph of luminosity versus temperature and draw 'isochrones', which are theoretical models for where all stars should be at different stages in their lives. And then you can see where the best fit is for the stars. It is a form of calibration tool.

We know that younger stars have more X-ray luminosity per unit of total luminosity – perhaps a thousand times more than the Sun does. And curiously, these stars also rotate faster. We can measure this by noting the change in brightness of stars due to dark spots on their surface. So when you look at those stars, you find that the correlation I mentioned is there. The faster it rotates, the more X-ray luminosity it has.

What we're trying to understand is why stars produce less X-ray emission when they spin down, and what else might be correlated, and what might it tell us about the stars themselves?

We find that the X-ray luminosity is not only correlated with the rotation rate but also the strength of the star's magnetic field and its outflow, the equivalent of the solar wind. Our model kind of holistically describes how the field is produced, how the field produces X-rays, how it converts that energy into some combination of X-rays and outflow, and then how the rotation feeds into that. The field itself carries away the angular momentum when it gets strong enough. It acts like a drive belt and slows the star down, then you get less field, and less X-ray emission, which reduces the wind flow.

The things we predict are currently hard to measure, but as we study more targets, we should be able to refine the observations and theory. It is not quite at the stage where it is a precise ageing method, but if we have even more information about the winds, the magnetic fields, and the outflows together, then we can make it a more accurate tool.



High energy X-rays stream off the Sun; they appear green and blue in this image, made from combined NuSTAR and SDO data

NASA/JPL-CALTECH/GSFC

ABOUT ERIC BLACKMAN

Prof Eric Blackman researches a range of problems in theoretical astrophysics at the University of Rochester, New York. He has a special interest in the origin and dynamics of magnetic fields.

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The Southern Hemisphere in June

With Glenn Dawes

WHEN TO USE THIS CHART

1 JUN AT 00:00 UT
15 JUN AT 23:00 UT
30 JUN AT 22:00 UT

The chart accurately matches the sky on the dates and times shown. The sky is different at other times as stars crossing it set four minutes earlier each night. We've drawn the chart for latitude –35° south.

JUNE HIGHLIGHTS

Saturn reaches opposition on the 3rd so is at closest and brightest (mag. 0.0) for 2016. Its magnificent rings are wide at 41.8 arcseconds. Keep watch for the Seeliger effect; in the days leading up opposition the rings have been known to suddenly brighten. Although visible all the time, Saturn's moon Titan (mag. +8.5) is at conjunction, passing 1 arcminute from the planet four times in June. It's due north (superior conjunction) on the 6th and 22nd, and due south (inferior conjunction) on the 13th and 29th.

STARS AND CONSTELLATIONS

You may have seen the Fishhook asterism many times without realising it: it is the tail of Scorpius. It starts at mag. +2.2 Epsilon (ε) Scorpii, then sweeps around to the stinger, which is formed from mag. +1.6 double star Shaula (Lambda (λ) Scorpii) and mag. +2.7 Lesath (Upsilon (υ) Scorpii). This asterism was also known as Wei, the Chinese constellation of the tail. In this case it belongs to a dragon, Azure, and was used to mark the coming of spring.

THE PLANETS

The early evening is fortunate to have three bright naked-eye planets on display. Jupiter, in the northwest above the tail of Leo, sets around 23:00 EST mid month. At mag. –2.0, it easily surpasses most winter evening stars. Only Mars in the eastern sky comes near its brilliance, outshining mag. +1.1 Antares (Alpha (α) Scorpii) and Saturn. Mercury is having a favourable morning apparition. Dropping between the Hyades and Pleiades clusters mid month, it is lost in the Sun's glare by the end of June.

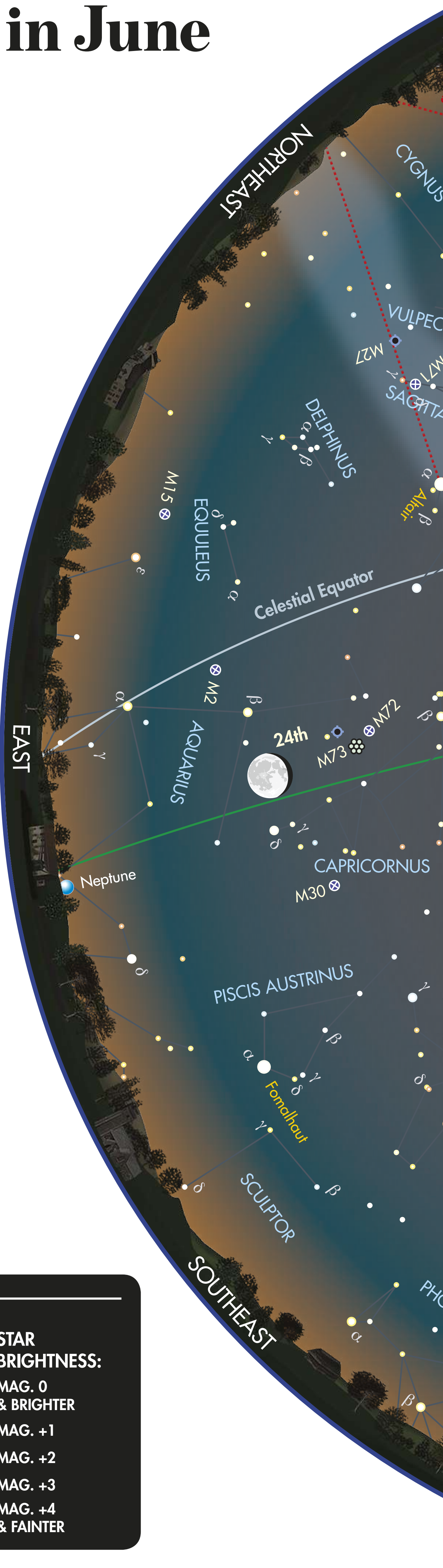
DEEP-SKY OBJECTS

Located 6° north-northwest of the Teapot asterism's lid star, mag. +2.8 Lambda Sagittarii, is M24 (RA 18h 18.4m, dec. –18° 24'; pictured). Known as the Small Sagittarius Star Cloud, this clearing in the numerous dark nebulae gives a glimpse beyond. Visible to the naked eye, the flattened glowing oval-shaped region (approximately 2x1°) is a brilliant binocular or wide-field telescope target. The immensely star-rich region offers everything – open star clusters such as NGC 6603, curving lines of stars, numerous double stars and nebulae. It leaves a definite 3D impression and a feeling that no matter how large the instrument there will always be hundreds more stars just beyond visibility. On the northern edge lies the distinctive pair of dark nebulae, B92 and B93. These circular black areas are each around 1-arcminite across.

CHART KEY

GALAXY
OPEN CLUSTER
GLOBULAR CLUSTER
PLANETARY NEBULA
DIFFUSE NEBULOSITY
DOUBLE STAR
VARIABLE STAR
COMET TRACK
ASTEROID TRACK
METEOR RADIANT
QUASAR
PLANET

STAR BRIGHTNESS:
MAG. 0 & BRIGHTER
MAG. +1
MAG. +2
MAG. +3
MAG. +4 & FAINTER



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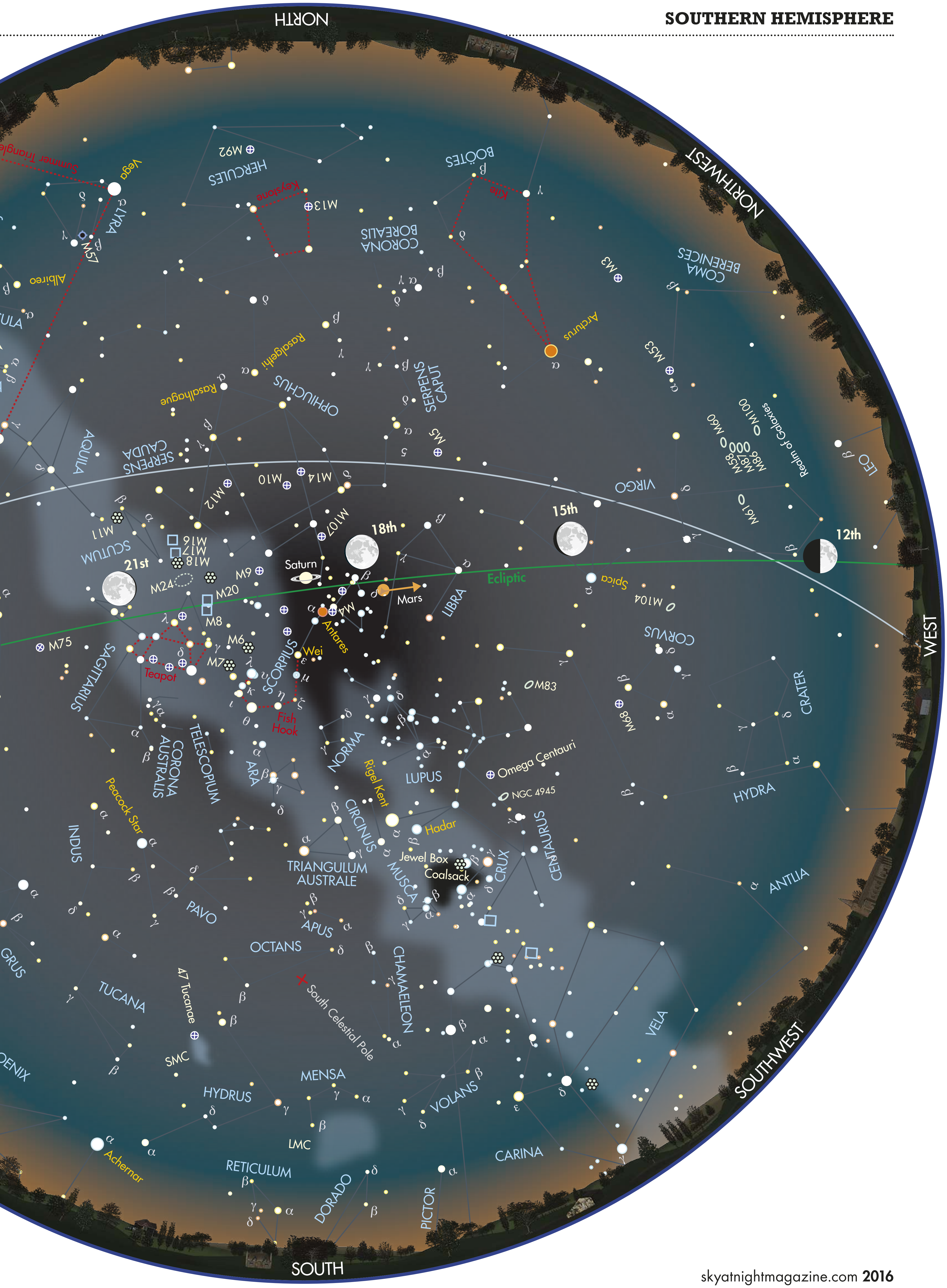
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SOUTH
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HERCULES
M92
Keystone
M13
BOÖTES
Kite
CORONA BOREALIS
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M4
Mars
LIBRA
Ecliptic
Spica
M104
M8
M75
M6
M7
Antares
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SCORPIUS
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SAGITTARIUS
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47 Tucanae
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